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JOURNAL

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SHEEP SHEARING TECHNIQUE

By

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And

D. A. Young, Shearing Instructor.

ONE of the biggest single handicaps to the sheep and wool industry is the shortage of skilled shearers and the direct and indirect loss as a result of this lack of skilled tradesmen runs into hundreds of thousands of pounds annually. The standard of shearing in Western Australia can be described as poor compared to the general standard which existed 15 to 20 years ago and any improvement that can be effected will be of considerable benefit to the industry.

Shearing demonstrations and instruction which was given in the main sheep-wheat districts last year revealed the definite need of **all** young shearers for expert instruction and advice in the correct technique. The demonstrations and instruction proved of great practical assistance to many farmers' sons and others, who, as a result of receiving expert instruction, were encouraged to take up shearing for the first time. The practical instruction already given is now supplemented by this article.

GENERAL DESCRIPTION OF CORRECT STYLE AND POSITION.

When catching a sheep for shearing select the one you are going to shear as you walk into the catching pen. With the right hand under the jaw and the left hand on the hip or top of tail press downwards and sit the sheep up. Then hold the right front leg in your right hand, the left hand on the side of the jaw, and going backwards pull the sheep along in a sliding manner in the direction of the shearing stand. The sex of the sheep is revealed while bringing it out on to the board.

Start shearing the belly wool first. The first blow starts down the right side, then open that blow to clear the way for cross-shearing, keeping in mind the veins and the danger of cutting. Make the blows in a round-turn style which gives a nice finish to the work. Clear inside the legs then move yourself towards the tube to secure the right angle to shear back along the first hind leg. Pressing the left hand on the flank, shear back over the tail to avoid dumping the sheep on the right side. While shearing it is necessary to remember to keep the bottom teeth of the comb on the skin all the time to avoid second cuts. The bent teeth should just peep out of the wool—this is what is called "filling the comb." Keeping down on the skin is the shortest way over the sheep.

Standing up, put the right foot between the sheep's legs. Hold the sheep tight with your legs and shear straight up the neck. Do not wrap the sheep's head around your leg and stop the animal breathing. Sit the sheep in a balancing position. Shear around the side of the face and the ear and make about two blows around the top of the neck. Endeavour to shear as much wool as possible without lifting the machine off the sheep and eliminate all unnecessary blows and second cuts.

In coming down over the first shoulder to the long blow, grasp the front leg with the left hand, pressing in tightly with the elbow and steady the sheep around into correct position. Do not kneel on the sheep and place the sheep straight along the board. Make three blows from the flank to the shoulder point, then run the machine from the hip joint to the top of the head and so on over the full length of the sheep.

In coming up from the long blow do not bring the right leg through the fleece. Rest the sheep's head on the left knee and while so doing shear over the head and down the other side—bringing the sheep back to the point where you can hold it with both knees you shear on to the last shoulder. After passing over the last shoulder bring the sheep up in front of your legs and get right in behind it with both feet. After completing the last front leg shear down the last side in a cross-stroke style, filling the comb all the way and not making any second blows, finish off in a free and easy manner leaving a compact fleece for the picker-up to throw on to the wool rolling table.

DETAILED DESCRIPTION OF CORRECT STYLE AND POSITION.

Fig. 1.
Catching sheep correctly.

Fig. 1.

The correct way to catch the sheep is to place the right hand under the jaw and the left hand on top of the tail. Then move the sheep back and press slightly down with the left hand and at the same time lift with the right. Do not try to throw the sheep while standing still, always keep the sheep moving back and in this way its hind legs will collapse under it. By keeping the sheep's head up with hand under the jaw it is possible to exercise a large measure of easy control. The reverse applies when the sheep's head is down.

Fig. 2.
Sheep being taken to machine.

Fig. 2.

The moment the sheep falls back you step quickly in behind it and take up your position to remove the sheep from the catching pen with the left hand on the side of the jaw and the right hand holding the leg. The more you can walk the sheep backwards as you throw it the shorter the distance to carry.

Fig. 3.
Sitting sheep in place ready to commence shearing.

Fig. 3.

In sitting the sheep in place ready to commence shearing the correct position is right opposite the universal joint and turned slightly away. Bring your back nearer the tube, and stretch the sheep up holding it with your knees until the removal of belly wool is completed. Do not lift the sheep clear of the board as this will cause it to kick.

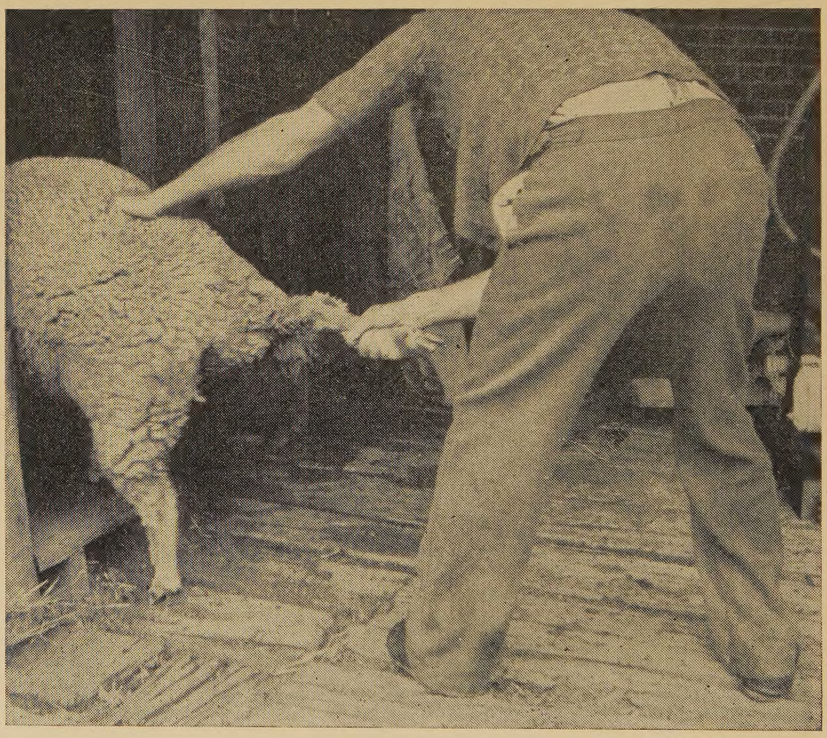


Fig. 4.
Legging sheep out of pen—Wrong.

Fig. 4.

It is quite wrong to leg a sheep out on to the board. Catching sheep in this manner wastes time and effort and is injurious to the sheep.

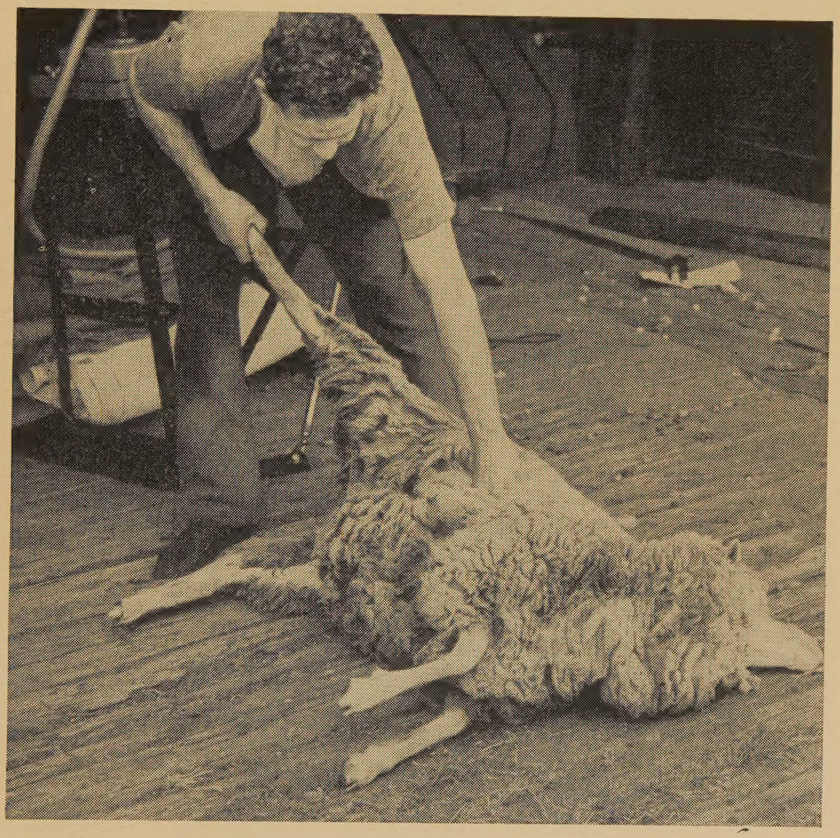


Fig. 5.
Legged sheep on board—Wrong.

Fig. 5.

The result of faulty catching by legging on to the board is here clearly illustrated.

Fig. 6.
Correct position for start of shearing.

Fig. 6.

The belly wool is first shorn and this illustration shows the correct position for starting to take the belly wool off. Stretch the sheep up and grip firmly with the knees. The shearer's right hand is pointing to the direction of the first blow which starts at the bare patch under the right front leg and continues on down to the flank. Open the wool away for cross-shearing as the belly should be shorn with cross and not downward blows. Shear from the first blow to the opposite side and continue until the belly wool is shorn off. Do not shear too big a belly wool as this will cut into the fleece wool which is unprofitable. When shearing the bottom of the belly care must be taken not to cut the teats of ewes and this is avoided by placing two fingers of the left hand over the teats. Obviously a ewe that is unable to suckle a lamb through damaged or "blind" teats is of greatly depreciated value in a flock.

Fig. 7.
Wrong position for start of shearing.

Fig. 7.

This position is wrong in that the sheep is too far in front of the tube. The sheep is out of position and this will affect the execution and timing of the blows—it is impossible to perform good or fast work in this position.

Fig. 8.

Shearing belly—Wrong.

Fig. 8.

This is the wrong way to take off the belly. The shearer's knee and weight is on the sheep's stomach and the sheep is rolled back off its buttocks. Note the awkward crouching position of the shearer which is quite wrong.

Fig. 9.
Shearing belly—Correct.

Fig. 9.

This illustrates the correct way to shear the belly wool. Starting from the right side follow the skin with the comb across to the left side—filling the comb on every stroke. Use cross and not downward blows in this position. Note shearer's grip on handpiece. Always grip the handpiece well back to give a longer reach and full control.

Fig. 10.
Finishing belly—Correct.

Fig. 10.

Finishing the belly, place the wool on one side, and then let the sheep fall slightly back in order to reach the inside shearing of the hind legs, which is done whilst still in the same position.

Fig. 11.
Shearing the crutch—Correct.

Fig. 12.

Finishing the crutch and cleaning inside of first hind leg—Correct.

Figs. 11 and 12.

Illustrate the correct way to shear the crutch. Hold the left hand over the udder of the sheep (Fig. 11) and shear around the crutch and out the first hind leg. Note position of the shearer's left hand which gives a straightening action to the sheep's leg (Fig. 12).

Fig. 13.
Opening up the first hind leg on the outside—Correct.

Fig. 14.

Opening up the first hind leg on the outside—Correct.

Figs. 13 and 14.

The shearer now changes his position and keeps the sheep well relaxed as he opens up the first hind leg on the outside and shears down towards the tail. Note how the fleece has not been broken into while shearing in this position. The shearer's left hand is keeping the sheep's leg straightened.

Fig. 15.
Shearing over the tail—Correct.

Fig. 15.

It is necessary to shear over the tail when in this position. Neglect to shear carefully over the tail whilst in this position can cause injury to ewes and difficulty when finishing off (see Fig. 33). If the flock being shorn have "long" tails, it is important that the tail be shorn efficiently and cleanly otherwise the protection from fly strike thus provided can be lost.

Fig. 16.
Opening up the first hind leg on the outside—Wrong.

Fig. 17.

First hind leg on the outside opened up—Wrong.

Figs. 16 and 17.

These two photos illustrate the wrong method of opening up the first hind leg on the outside. Note how the shearer is cutting into the fleece as a result of holding the sheep's leg in the wrong position. Holding the leg in this manner will irritate the sheep and make it kick. Shearing from this position and in this manner makes a very bad start when turning for the long blow and also brings about second cuts. The sheep has been shorn too high and wide on the rump and in Fig. 17 the shearer is taking the top-knot off after having gone past the tail without shearing over it. Note how the fleece has been broken out. This is wrong and makes it practically impossible to pick up and throw the fleece correctly. This leads to faulty and slower work on the wool rolling table which, of course, is reflected throughout the whole of the wool room. Good work on the wool rolling table is the foundation of good classing, and faulty skirting and backing proves costly to the grower.

Fig. 18.
Shearing up the neck—Correct.

Fig. 18.

A change of position is necessary for shearing up the neck correctly, and the altered position of the sheep and shearer is clearly illustrated. Always shear up the neck with the sheep relaxed and in a balanced position. The first blow is up the **centre** of the neck and then shearing down towards the shoulder. Always start every blow from the brisket point. Never idle the time when you have a sheep between your legs, and **do not** use the sheep for a resting post while shearing. A shearer is more likely to have the machine kicked out of his hands in this position than in any other—so to avoid this and injury to his stand mate it is essential to hold the sheep correctly when shearing up the neck.

Fig. 19.
Shearing up the neck—Wrong.

Fig. 19.

This position illustrates the wrong way to shear up the neck. The shearer and sheep are in a position which is both wrong and dangerous and could lead to a nasty accident to anyone on the board. Note shearer's right knee and weight on sheep and awkward crouching position. Note sheep's head and neck bent well back over shearer's left knee and shearer's hand over sheep's muzzle. This will stop the breathing of the sheep and cause it to kick and fight. Faulty neck shearing in this manner results in second cuts, skin pieces, cut sheep, and lower tallies, all of which represent a definite loss to both grower and shearer.

Fig. 20.
Over the first shoulder—Correct.

Fig. 20.

The shearer's position is again changed when shearing the first shoulder in preparation for the long blow. In this position the sheep is held entirely by the left hand with the elbow against the neck steadying and holding the position. Note how the neck and shoulder has been shorn well back and neck wrinkles cleaned out so that this part of the sheep will be excluded from the long blow. Ridging and second cuts will occur if this part of the sheep is included in the long blow. Fig. 20 illustrates practically the last blow before turning for the long blow.

Fig. 21.
Balancing sheep for the long blow—Correct.

Fig. 22.
The long blow—Correct.

Figs. 21 and 22.

These positions illustrate how the sheep should be balanced whilst performing the long blow which is practically a matter of balancing the animal with the right leg and left hand. All that is necessary in this position is to keep a straight blow and a full comb whilst making the strokes from tail to head. Kneeling on the sheep is not necessary. Kneeling on a sheep enlarges the area to be shorn, causes delay in gaining position as shown in Fig. 22 and in addition can make the sheep kick and become injured.

Fig. 23.
The long blow—Wrong.

Fig. 23.

This illustrates the wrong way when performing the long blow. The shearer is kneeling on the sheep with the front leg held down and around the animal's head. This style is commonly used and is entirely wrong.

Fig. 24.
Completion of the long blow—Correct.

Fig. 24.

Here the shearer is finishing the long blow with ease and in the correct way. The sheep is comfortable and the fleece intact and in one piece.

Fig. 25.

Coming up from the long blow and finishing head—Correct.

Fig. 25.

The shearer's position is changed slightly when coming up from the long blow and finishing the head **without dragging the foot through the fleece.** To achieve this blow and position it is necessary to bring the sheep's head back with the left hand and with the shearer's left leg dragging the front portion of the sheep back. At the same time the shearer's knees are slightly bent and he is temporarily raised on the toe of the right foot which is between the rump and the board and is assisting to hold the sheep firmly in position. Note the full control the shearer has over the sheep. Note the unbroken fleece.

Fig. 26.
Coming up from long blow and finishing head—Wrong.

Fig. 26.

This position illustrates the wrong method when coming up from the long blow and finishing the head. Note the broken fleece caused by the shearer dragging his right foot through it when finishing the head. Compare this fleece with that shown in Fig. 25. This style of shearing is frequently used, but with considerable loss to the grower. It will be impossible to correctly pick up, throw, skirt, back and roll the fleece illustrated in Fig. 26. This fleece will either be over skirted and/or over backed, or under skirted and/or under backed with loss to the grower in either case. It will be impossible to roll the fleece which will eventually be placed on the classer's table as a heap of broken wool with considerable "bloom" lost and difficult to assess and handle. In addition to this loss, badly entangled and broken fleeces considerably slow up the work of all in the wool room which can lead to frayed temp ers and faulty work generally in an effort to catch up with the work and keep the wool away.

Fig. 27.
Shearing over the last shoulder—Correct.

Fig. 27.

The position of shearer and sheep is again changed when finishing the neck and shearing over the last shoulder. The sheep is held firmly where it cannot move to an easy position with the head between the shearer's legs. It is necessary to shear **round** the shoulder. Do not use **downward** blows.

Fig. 28.
Completing the last front leg—Correct.

Fig. 28.

The previous position is followed by completing the last front leg with the sheep well controlled between the knees and the left hand—leading to the whipping side (Fig. 29). Cleaning the top of the leg should be done with outward blows and not downward blows into the arm pit. There is danger of cutting an important artery in the arm pit if the blow is downward.

Fig. 29.
Beginning the whipping side—Correct.

Fig. 29.

This position illustrates the last front leg correctly finished and the beginning of the whipping side or last side.

Fig. 30.
The whipping side—Correct.

Fig. 30.

The shearer now changes position by placing both legs together behind the sheep and bringing the animal sitting straight up with the left hand on shoulder point. With the left hand holding the sheep in position run the blows towards the flank using a cross blow. At the same time bend the sheep slightly back. Do not use downward blows on the last side. Note the comfortable and relaxed position of the sheep.

Fig. 31.
Shearing the last hind leg—Correct.

Fig. 31.

The last hind leg is next shorn by placing the left hand in the flank which straightens the leg and protects against hamstringing. Run the blows from the backbone to the hoof and gradually move the feet back from under the sheep a little, allowing comfort for the animal and in preparation for the finishing blows (see Fig. 32).

Fig. 32.
Finishing off—Correct.

Fig. 32.

This illustrates the correct position for the finishing-off blows. The sheep is comfortable and still under full control.

Fig. 33.
Finishing off—Wrong.

Fig. 33.

This finishing-off position is wrong in every way and is the result of being out of correct position and not cleaning over the tail on the first side. Compare position of shearer and sheep with Fig. 32.

Fig. 34.
Letting go—Correct.

Fig. 34.

The sheep is now shorn and ready to be turned out and the correct letting go position is illustrated. The sheep is still under full control with the right hand around the tail forcing it forward and the left hand guiding the animal out. When shearing rams always let go around the shearer's left leg. Note how well the fleece is being left—in a compact and unbroken condition.

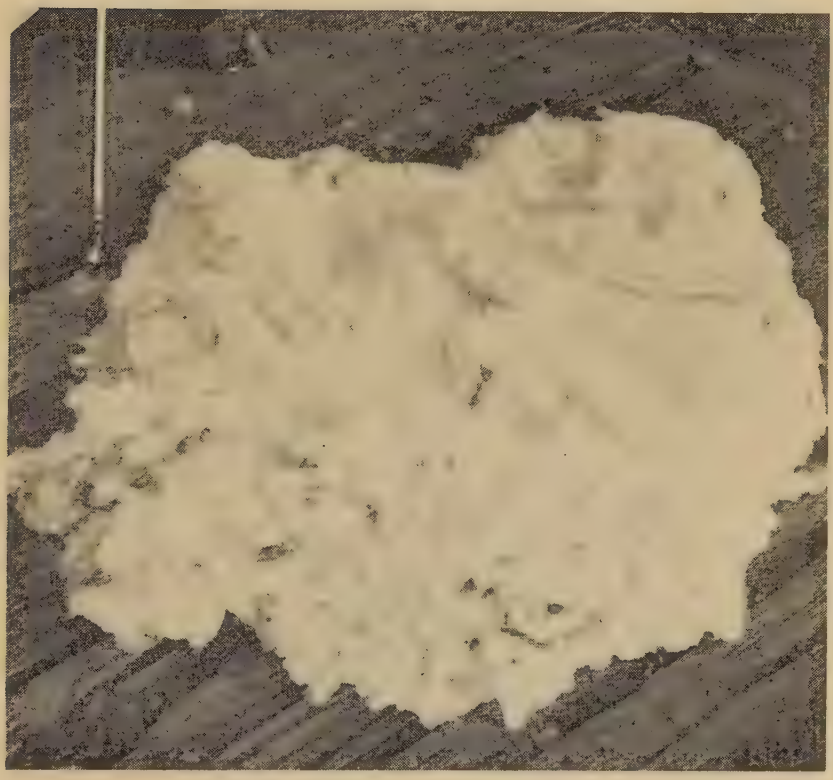


Fig. 35.

Shorn fleece as left for picking up—Correct.

Fig. 35.

The sheep has now been let go and the position and splendid condition of the shorn fleece illustrates the result of skilled shearing and good tradesmanship. The fleece has been left correctly for picking up and as a result it is possible to throw, skirt, back, roll and class the fleece with a maximum of efficiency and a minimum of time.

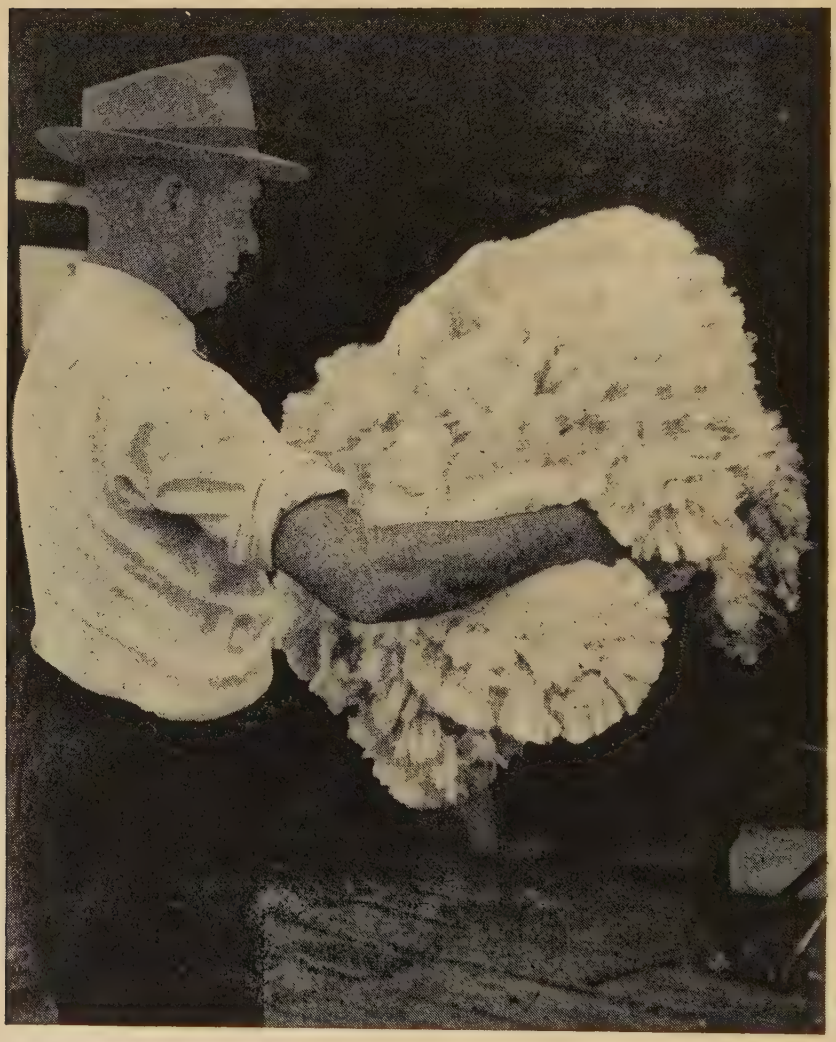


Fig. 36.

Picking up—Correct.

Fig. 36.

The fleece has now been picked up correctly and is ready for throwing and treatment by the wool rollers. Good shearing has made it possible to pick up and throw the fleece correctly. The fleece is intact and in one piece throughout from britch to neck.

HOLDING HANDPIECE CORRECTLY.

It is important to grip the handpiece as far back as possible. If this is done it will give better control, particularly in hard-shearing sheep, a reduced amount of wrist movement and a longer reach. Always remember to keep the right hand side of the comb (which is commonly known as the bottom tooth) down on the skin with every stroke that is done. This will eliminate what is known as "weather board" shearing and second cuts. Obviously it is also the shortest way over a sheep.

BALANCING A SHEEP.

To balance a sheep means to have the animal sitting in a correct position in order to prevent undue strain on the shearer. This should be done by gripping the sheep with the knees only, which gives the left hand freedom to change the sheep into place in order to keep the right hand shearing without loss of time.

FOLLOWING SHAPE OF SHEEP.

The first step in shearing is to concentrate on the point of the comb and to develop a sensitive touch with the machine and an even pace with correct timing of strokes. Work should always be kept in an open faced style without cramping or fumbling. Always wait for the swing of the tube when making the blows.

CARE IN HANDLING SHEEP.

Under no circumstances should the shearer hit or kneel on the sheep.

When bringing an animal out of a pen care should be taken to keep it down on the board. Lifting it clear makes heavy work (particularly towards the end of the day) and often starts the sheep kicking and straining. This causes a loss of grip and grabbing of the wool which then tears from the skin. The performance of good fast shearing is dependent upon full concentration on the work that you are doing and not allowing yourself to become heated or upset over minor incidents whilst shearing.

Do not try to shear a lot of sheep when just starting. A good learner often takes two seasons before shearing over his first 100 sheep. Take extra time to learn thoroughly, and make a study of shearing during your first few seasons. This will pay handsome dividends later on in the form of high tallies for less effort. After shearing the two hour run it is a good idea to look over your sheep in the counting out pen and compare them with other good shearing and try to improve on your own style. Shearing is mostly judged on the way the fleece is taken off and absence of cuts on the sheep.

CARE OF HANDPIECE.

The handpiece is the responsibility of the shearer as he uses it eight hours a day. An important part of the handpiece is the post gauge—one of which is made for every machine. Post and machine adjustment is necessary before starting to shear, particularly with new combs and cutters. Post gauges should be used on the handpiece at least once a week after shearing is under way, in order to have the fork at the correct level for smooth and efficient working. The tension nut should be kept clean and cleaned every two hours. Do not fill the tension nut with grease.

COMBS AND CUTTERS.

Do not use standard combs and cutters with wide throw combs and cutters. Use either all standard tools or all wide throw tools. It is essential to have a comb that enters the wool easily without jabbing, enabling the shearer to keep down on the skin.

When selecting the shearing combs and cutters, before starting to work with them, try the points of the combs on the hand—holding the comb with the right hand to find the sharp points on the comb teeth. If there are any sharp points use a worn piece of emery paper and just dull the sharpened points, then strop the comb on a piece of soft wood or leather.

COMB LEAD.

When setting the comb on the handpiece and the cutter, always see that there is the correct distance from the point of the comb back to the point of the cutter. This can be adjusted by putting both comb and cutter together and turning the machine from the back cogs with the right hand. It is also necessary to have the teeth of the cutter timing correctly with the teeth of the comb. It may be necessary to stand the comb up a fraction in front of the cutter point. This will give sufficient combing lead to shear with efficiency.

GRINDING.

Good fast work is impossible without good grinding, particularly in hard-cutting sheep. It is essential that the grinding be done in a good light. The discs must be made correctly and the pendulum adjusted correctly, so that the setting of the pendulum just reaches to the centre of the disc. When making the discs be certain that the emery paper is set only in even and level glue. The glue should not be lumpy or uneven when spread on the disc. It is also necessary to check the speed of the grinder. Good grinding cannot be effected if the speed of the grinder is too slow.

Do not over-heat or over-sharpen combs or cutters. When tools are over-sharpened a saw-like edge can be noticed along the cutting face—this indicates that too much pressure is being applied on the pendulum. To avoid this it is necessary to stand well back from the emery wheel—at arm length in order to give a correct pressure on both hands. When combs and cutters are over-sharpened there is a softening of the steel facing which only bluntens and wears, without good cutting, when the tools are used. When combs and cutters are blunt a white dull edge appears where they have been constantly cutting wool. After being sharpened correctly the white dull edge disappears and is replaced by a clear-cut edge.

To achieve these results always grind in a good light on well made discs, using an even pressure and very little weight.

NUTRITIONAL REQUIREMENTS OF THE DOMESTIC FOWL

R. H. Morris, Agricultural Adviser.

IN recent years research workers have made considerable progress in determining the nutritional requirements of the domestic fowl. Deficiencies or excesses of different nutrients have been shown to cause disease. The food needed by birds of different ages has been shown to differ and the most economical levels to supply various nutrients to poultry have been fairly well defined.

The purpose of this article is to outline the fundamentals of poultry nutrition, to suggest sound practical rations that might be fed to poultry of different ages, and to explain why these particular rations are recommended; the explanations being based on our present knowledge of poultry feeding. It is proposed to cover only the more important aspects of poultry nutrition with which the practical man is concerned. For readers who wish to further study the science of poultry feeding, the references given should be helpful.

Feeding costs have been estimated to account for approximately 50 per cent. of the total costs of production on the average poultry farm. It is, therefore, of primary importance that the poultry farmer should use the feeding materials that he has at his disposal to the best possible advantage. To do this he must be conversant with the principles of poultry nutrition and with the progress that has been made in this field.

Although the potential egg laying capacity of a fowl is determined by its inheritance, the number of eggs laid within this capacity is largely dependent on the quantity and quality of food eaten.

Food is used for three purposes—

1. For body maintenance.
2. For growth.
3. For egg production.

Food required for Maintenance and Egg Production.

The first call that poultry and, in fact all livestock, make on food which they eat is for the maintenance of their bodily functions, that is the maintenance of body weight, normal body temperature (106.5°F—107.5°F in the fowl) normal muscular activity and the repair of waste tissue. The ingested food which is in excess of that required for maintenance is used for growth by young stock, production of feathers by moulting birds, and the production of eggs by laying hens.

The feeding of a maintenance ration which keeps the birds in apparent good health is insufficient if we expect to obtain optimum results from our birds and to make a profit. Optimum results will only be obtained if the birds are fed nutrients of the proper quality and in amounts known to be necessary for various forms of production over and above those which are required for maintenance.

The maintenance requirement is dependent on the size of the fowl. The larger the fowl the greater the maintenance requirement. The maintenance ration of a light breed pullet weighing 4 lb. is approximately 2.4 ounces of feed per bird per day, and of a heavy breed pullet weighing 6 lb. approximately 3.2 ozs per bird per day.

It has been found that after the maintenance and growth requirements of a hen have been met, the feed required to produce a 2 oz. egg is between 1.2 and 1.6 ozs. or an average of 1.4 ozs., which is considerably less than the amount of food required for maintenance. In addition to the dry food approximately 1½ ozs. of water are required to produce a 2 oz. egg. Therefore it follows that the total feed cost per egg produced is much less when the average production of a flock is high than when it is low. Therefore the efficiency of food utilization for egg production, or the number of eggs produced per unit weight of feed consumed, increases as egg production increases.

A fully grown pullet when laying an egg every second day uses nearly three fourths of her feed supply for maintenance for ordinary muscular activity and to maintain her body temperature. As this amount of feed has to be provided day after day whether the flock is laying well, poorly, or not at all, it clearly is an advantage to own productive hens and to keep them laying.

Baby chicks do not require very much food for maintenance but as they grow the demand for food for this purpose becomes progressively greater.

Present-day difficulties experienced by Western Australian producers in obtaining poultry foodstuffs at reasonable prices demand very heavy culling of flocks by those engaged in the poultry industry, in order that the returns received should be comparable to those received by producers of ten years ago.

Intelligent culling and correct feeding of laying flocks are two of the most important farm practices contributing towards economic egg-production.

The art of feeding is firstly to provide the birds with a balanced ration, and secondly to ensure that they eat enough of that ration to meet their requirements. Fowls which lay large numbers of eggs require large amounts of food, and production will decrease if the food intake is restricted in any way. Full feeding of a balanced ration pays. The amount of food eaten at different times of the year will vary according to the production of the flock. Large amounts will be eaten during the spring months and considerably less during the autumn months when the fowls are moulting. The weather and the method of housing will also affect the quantity of food consumed.

Should laying birds go off their feed for any reason an attempt must be made to restore their appetites immediately. Stale food will very often put the birds off their feed. Especially is this found with wet mash that has been allowed to accumulate in the troughs and which becomes sour. Poisoning and severe enteritis are likely to accompany this practice. Where wet mash is fed the appetite of the flock needs careful watching by the attendant and the quantity fed each day should be sufficient for the birds to clean up within thirty minutes. With a wet mash-grain system of feeding, a kerosene tin full of wet mash containing two-fifths by volume of green-feed will be the approximate amount required per day by 80 laying fowls, providing dry mash is available in the hoppers.

Providing a balanced ration is fed it is impossible to overfeed poultry. Never restrict the amount of feed. There is sometimes a tendency to do this when the price of eggs is low and that of food is high. Restricted feeding will result in lowered egg-production, and greater amounts of feed consumed per dozen eggs laid—hence lower net profits. In one experiment reducing feed intake of laying hens to seven-eighths of the amount eaten by birds which had free access to food, decreased the number of eggs laid from 182 to 124 eggs per hen per year and increased the amount of feed consumed per dozen eggs laid from 4.4 lb. to 5.6 lb.

Classification of Food Nutrients.

Foodstuffs vary greatly in value according to the proportions of essential nutrients they contain. These nutrients may be classified as follows:—

1. Proteins—essential for body-growth and egg-production.
2. Carbohydrates—the cheapest source of energy and warmth. May be converted to body fats.
3. Fats and oils—not important to poultry as sources of energy or fat, but may carry valuable vitamins.
4. Fibre—some roughage is essential for health, but too much is harmful.
5. Minerals—essential for building bone and producing egg-shells.
6. Vitamins—essential for normal health.
7. Water—vital to all living things.

PROTEINS.

Proteins contain the chemical elements carbon, hydrogen, oxygen and nitrogen. Some proteins contain sulphur and phosphorus and one of the blood proteins (haemoglobin) contains iron.

The average nitrogen content of most proteins is about 16 per cent. and use is made of this fact when determining the amount of "total" or "crude protein" present in a foodstuff. The nitrogen content of the foodstuff is determined chemically and is then multiplied by 6.25 since $100 \div 16 = 6.25$. The result is referred to as "crude protein." Part of the crude protein of any foodstuff is digestible and can be used by the fowl. Part is indigestible and, therefore, has no nutritive value. That part which is digestible is known as "digestible protein" and the true value of a protein lies in the amount of digestible protein it contains.

In general, animal products contain more protein than vegetable products. Animal proteins are of better quality than vegetable proteins and are more palatable. These features make animal proteins more valuable nutritionally than proteins from vegetable sources.

The soyabean is an exception to this rule as it is rich in protein and its protein closely approaches that from animal products in quality.

For best results animal proteins should be fed with vegetable proteins and at least one quarter of the protein content of the ration should be derived from animal sources.

Examples of foodstuffs rich in animal proteins, with their average crude protein content in parentheses are:—Bloodmeal (80 per cent.), meatmeal (35-50 per cent.), fishmeal (58 per cent.), dried buttermilk powder (30-35 per cent.).

Protein rich vegetable foodstuffs are soyabean meal (45 per cent.), linseed meal (35 per cent.), pea meal (23 per cent.).

The nutritive value of protein rich foodstuffs derived from animal products (commonly known as "animal concentrates") varies with the method of manufacture. Their value as a foodstuff is greatly reduced if they are subjected to excessive heat during manufacture. Excessive heat has a so-called "denaturing effect" on the proteins which renders them indigestible. "Vacuum" and "steam dried" protein rich foodstuffs, are more valuable than "flame dried" meals, since lower temperatures are maintained throughout the two former manufacturing processes.

Amino Acids.

There are many different proteins and all of them are composed of a relatively small number of comparatively simple compounds, called amino acids. Twenty-five amino acids are known and the chicken is capable of making some of these in its own body. The amino acids which an animal requires for normal growth and reproduction but is unable to make in its own body and which must, therefore, be supplied in the feed, are known as "essential amino acids." The available evidence suggests that 11 of the 25 known amino acids are required by the fowl in its feed.

A protein which contains the eleven essential amino acids is called a "complete protein" and is said to be of good quality and to have a high biological efficiency. A protein which does not contain all the essential amino acids is called an "incomplete protein." By supplying a number of different "incomplete proteins" in the diet it is often possible through their supplementary effect to form a "complete protein." The lack of particular amino acids in one protein is compensated by the presence of these amino acids in the other protein or proteins.

Before a feed protein can be utilised by the fowl, it has first to be broken down in the digestive tract by the appropriate digestive juices (refer page 86). Complete proteins are broken down into simple amino acids. These amino acids are absorbed into the fowl's bloodstream through the walls of the small intestine and are carried to the body cells which rebuild them into body protein, (flesh, feathers, eggs etc.).

The bulk of the dry matter of the animal body consists of protein and 25 per cent. of a fowl's live weight is protein. The muscles, internal organs, skin, feathers etc., are largely made up of protein and proteins also occur in the blood, nerve tissue and bone.

The tissues of the body are constantly being broken down and food protein must necessarily be provided if the fowl is to replace these tissues and maintain normal body weight. Egg production and growth considerably increase the demand for proteins and if birds do not receive an adequate supply of proteins containing the necessary amino acids these functions cannot be satisfactorily performed.

The prime function of protein in the animal body is to provide amino acids which are used to replace worn-out tissues and to build new tissues of which growth and egg production are examples. Any amino acids which are left over after these requirements have been met are "deaminized" or broken down in the liver, where part of the amino acids is turned into fuel and the remainder is excreted through the kidneys. Hence, food proteins can be used as a source of energy, but because protein rich foods are usually expensive it is more economical to use carbohydrates or fats for this purpose. Excessive feeding of proteins may also cause injury to the kidneys, so that in addition to being expensive this practice may be harmful.

Protein Requirements of Chicks.

When we consider that the unabsorbed yolk material present in the chick at hatching time contains a large amount of protein, and that wild birds feed their young largely on grubs and worms which are primarily protein, it is not surprising to find that research workers have proved that chickens in the first six weeks of their life, during which time they are making their most rapid growth, require a ration which contains a relatively high percentage of protein.

Results obtained by Titus (The Scientific Feeding of Chickens) in an experiment in which this worker compared the growth rates obtained from chickens fed a series of growing rations containing from 13 to 25 per cent. of protein, showed that the efficiency with which the feed was converted to body tissues gradually increased up to 21 per cent. of protein in the diet and then decreased. (See table 1). The diet which contained 18 per cent. of protein was only slightly less efficiently used than the one containing 21 per cent. protein.

Titus points out that a ration containing about 18 per cent. of protein may be more economical if its cost is sufficiently less than a ration containing 21 per cent. protein. It is interesting to note that the chickens in this experiment, which were on the 13 per cent. protein ration, eventually reached nearly the same weight as those reared on the 21 per cent. protein ration, but they took nearly 20 per cent. longer to reach the same weight and required nearly half as much feed again as those reared on the 21 per cent. protein ration.

The percentage increases in amounts of feed required to bring the chickens on the various diets to adult weight, as compared with those receiving 21 per cent. of protein in their ration were:—

Table 1.

Per cent. Protein in Ration.	Per cent. Increase in Food Required to Bring Chickens to Maximum Live Weight.
13	44*
14	21½
15	12½
16	8
17	4½
18	2
21	Optimum efficiency.
24	11½
25	17½

* Or nearly half as much again compared with the 21 per cent. protein ration.

Although the physiological optimum percentage of protein in the diet of a young chick from a growth-promoting point of view may be 21 per cent., it is possible, when protein concentrates are in short supply and expensive (as is the position in Western Australia today) and maximum growth rates are not highly desirable (as is considered to be the case with chickens which are ultimately to be used for egg production and breeding), to reduce the protein content of the ration for chicks 1-6 weeks of age to 15.5 or 16 per cent., and still avoid trouble from undesirable factors such as:—slow growth rates, poor feathering, greater susceptibility to disease, high mortality, feather picking, toe picking, and cannibalism; any one of which is likely to result from the feeding of too low a protein diet. (N.B.—The conditions listed above can result from many other incorrect feeding and management practices, apart from a protein deficiency, but these will not be dealt with at this stage.)

The feeding of low protein diets (approximately 13 per cent. for young chickens and below 13 per cent. for older chickens) to growing chicks, in addition to retarding growth, is invariably accompanied by delayed sexual maturity. The contention that this delayed sexual maturity enables a bird to gain a bigger body size before laying commences, and that egg size is, as a consequence, bigger, is not universally accepted. Because of the retardation effect that low protein diets

have on both body and sexual development, birds on low protein diets are, in fact, no bigger when laying commences than birds on higher protein diets, and the possibility of birds on low protein diets laying small eggs is, therefore, just as great as with birds on high protein diets.

Another experiment on the influence of protein level on rate of growth, using Barred Plymouth Rock chicks, yielded the following information:—

Ration.	1	2	3	4
Per cent. protein in the diet	9.8	13.5	17.3	21.1
Days taken to double initial weight of chicks	26	16	13½	11
Days taken to treble initial weight of chicks	47	27½	22	19½

Wherever possible the various classes of stock should be fed protein at levels approaching the optmium percentage recommended in Table 2. Because of the small amount of food consumed by the chicken early in life and because of the benefits that follow a good start in life it is important that a definite attempt should be made to feed protein at levels approaching the optimum level recommended in Table 2 to chicks 1-13 weeks of age.

Table 2.

SUGGESTED ECONOMICAL LEVELS OF PROTEIN FEEDING AS A PERCENTAGE OF THE TOTAL FEED CONSUMED.

Class of Stock.	Minimum.	Optimum.	Maximum.
Chickens—			
1– 6 weeks	14.5	16	21
7–13 weeks	14.5	15.0	18
14–22 weeks	13	14	15
Laying Hens	14	15–15.5	17
Breeding Hens	14	15–15.5	17
Breeding Cocks	13	14	15.5

A change of diet usually has an effect upon the growth or egg production of birds and in particular, a decrease in the protein content of a ration invariably has a marked adverse effect on the birds (except of course in the case of growing chicks, 7-13 weeks old, where the protein content of the diet is gradually reduced as they mature). The farmer should endeavour to keep the protein level of the ration constant for each class of bird. In some cases this requires a fair amount of skill as supplies of feeding stuffs are very often irregular. Good management and foresight can, however, sometimes even out such irregularities and the farmer is well repaid for any effort he may make in this direction.

Protein Requirements of Laying Hens.

Laying hens need a continuous supply of protein as the nitrogen required for egg production is largely if not entirely drawn direct from the food. An insufficient amount of protein will result in decreased egg production, lower body weight (flesh), and smaller egg size.

Although much research has been devoted to this particular aspect of poultry nutrition, it is not possible to state the exact protein level which is optimum for egg production. The general consensus of opinion is that a 14 per cent. level (providing 25 per cent. of the total protein is derived from animal foodstuffs) may be sufficient for fairly satisfactory egg production but should be regarded as a marginal rather than an optimum level, as body weight and egg size may not always be maintained on a 14 per cent. protein ration. The optimum percentage lies between 14.5 and 16 per cent. protein in the ration, when we take into consideration such factors as egg numbers and size, and maintenance of body weight (flesh). Where protein concentrates are costly and difficult to obtain a 15 per cent. level of protein in the diet should give satisfactory production.

The feeding of very high protein diets (16-18 per cent. protein) may result in the laying of a few more eggs but cannot be recommended under present day conditions. On the other hand there is evidence to suggest that many engaged in the Western Australian poultry industry are feeding rations to their laying hens which contain from 13-13½ per cent. of crude protein. This is a most uneconomical practice.

Protein Requirements of Fowls of Different Weights.

It has been the practice in this State for many years to feed heavy breed hens a slightly higher percentage of protein than light breed hens for the following reasons.

1. The heavy breed hen (e.g. Australorp) has more body tissue than the light breed hen and needs more protein to keep replenishing this tissue as it is constantly being worn away.

2. The light breed hen (e.g. White Leghorn) is naturally a more active bird and because of this uses more energy than the heavy breed hen. In other words the light breed hen requires a higher percentage of carbohydrate rich foodstuffs in her diet than does the heavy breed hen. In practice this is accomplished by feeding the light breed hen a ration which is slightly lower in protein.

3. Generally speaking the Muresk Egg Laying Trial results over the years indicate that Australorp pullets in this State are likely to lay more eggs than White Leghorn pullets, so that on the average heavy breed pullets have a greater demand for protein than the light breed pullets.

N.B. The above statement does not imply that the Australorp breed in this State is superior to the White Leghorn breed. The position, as the writer sees it, with regard to the two most popular egg laying breeds in W.A. today, is that birds from a good laying strain of Australorps are likely to produce more eggs than the same number of birds from a good laying strain of White Leghorns in their first year, but will also eat more food than White Leghorns. As a general rule heavy breed hens at the end of their first year of lay require heavier culling than do light breed hens of the same age, if satisfactory production is desired from the fowls in their second year of lay. This is because of the tendency on the part of the Australorp hen to become excessively fat during the moulting period even when she is fed a ration which would normally be regarded as containing adequate protein.

It is impossible to make a straight out comparison between breeds. Too much time is devoted to discussions on the relative merits of breeds not only with poultry but with all classes of livestock. More emphasis should be placed on "the strain." The inherent ability of a fowl of any breed to lay is determined by its genetic constitution and not by external features which we use to distinguish breeds of fowls. Good and bad strains occur in all breeds. To be successful the

poultry farmer has first to select birds from a good egg laying strain, preferably of a breed for which he has a natural liking, and then house, manage and feed those birds correctly.

The shortage of protein concentrates (meatmeal in particular) has to a large degree been responsible for the increased popularity of the White Leghorn breed in this state of recent years.

Because of the three reasons given above, the protein levels of rations, (see page 76) fed to the trial birds (all pullets) at Muresk, vary according to the class of bird being fed.

Under farm conditions it is not practical to continually take analysis of the fowls feed and different batches of the same foodstuffs may vary considerably in food value so that providing the ration contains between 15 and 15.5 per cent. protein, both heavy and light breed hens should give satisfactory egg production. When light and heavy breed hens are kept on the same farm it would be advisable to feed a slightly higher level of protein to the heavy breed hens.

Of recent years the "first cross" hen (progeny of White Leghorn cock X Australorp hen) has become increasingly popular as an egg producer in this State. "First cross" chickens are hardy and easy to rear. They tend to mature early but the neck moult which may occur as a result of this, and which is often seen in April in pullets which commence laying in January, is not nearly so severe as in pure bred hens (particularly White Leghorns) and egg production is, as a rule, only slightly affected. Providing the birds which are mated to produce the "first cross" are from good egg producing strains the resulting female progeny will develop into laying hens that excel at egg production and in this regard a flock of them will compare more than favourably with the majority of pure bred hens.

The importance of mating two good pure bred strains cannot be overstressed. "First cross" hens which result from the crossing of the sub-standard parents will themselves be inferior. "First cross" stock should never be used as breeding stock.

The cross, Australorp cock X White Leghorn hen is not recommended because of the high incidence of broodiness found in the female progeny.

The food requirements of first cross hens are the same as for Australorp hens.

How to Assure Protein Quality in the Ration.

We have seen that animal protein concentrates are, as a rule, richer sources of protein than foodstuffs of vegetable origin and that the quality of proteins derived from animal sources are, when taken as a whole, superior to proteins derived from vegetable sources. This would suggest that a certain percentage of the total protein contained in the ration should be of animal origin. Feeding trials with different classes of poultry (hens, chickens etc.) have indicated that one quarter of the total protein supplied should be of animal origin, i.e. derived from meatmeal, liver meal, fish meal, milk by-products, etc. Providing the farmer sees that this requirement is met there should be no concern with regard to the quality of protein in the ration.

In America fairly satisfactory results were obtained with both growing chickens and laying hens when soyabean meal was the only protein supplement fed. However, in order to obtain results comparable to those obtained from birds fed rations which contained animal protein, it was found necessary to increase the protein content of the rations which contained only vegetable proteins by 25

per cent. Also, because of the low vitamin and mineral content of the soyabean meal as compared with animal protein rich foodstuffs it was found necessary to make special provision for these nutrients when compounding the ration.

N.B. The terms "ration" and "diet" used in this article refer to the total food consumed.

Meatmeal Supplies.

At the present time a peculiar position exists in this State with regard to meatmeal. Locally produced meatmeal costs approximately £17 per short ton, while meatmeals imported from the Eastern States of Australia are priced at from £34-£40 per short ton. In order to feed their fowls levels of protein associated with balanced rations, the average Western Australian producer has to make use of imported meatmeals. Producers in this State should have little difficulty in obtaining one quarter of their requirements of meatmeal from local sources. There is a possibility that because of the high price of imported meatmeals compared with local meals, the producer is reluctant to buy imported meatmeal in sufficient amounts that will enable him to feed sufficient protein to his fowls for most economical production. The purpose of this section is to show that it pays to purchase the high-priced meatmeals even at £40 per ton, in order to supplement that which is available locally.

Under an all-mash system of feeding, and where wheatmeal forms 80 per cent. of the mash, the cost of locally produced meatmeal required to balance one hundred pounds of the mash (15.75 per cent protein) would amount to 2s. 4½d. Where the meatmeal comprises 75 per cent., £40 per ton meatmeal and 25 per cent., £17 per ton meatmeal—the cost of the total meatmeal required would be 4s. 9½d., making a difference of 2s. 5d. between the two rations. This in terms of eggs represents approximately 1¼ dozen. One hundred pounds of the mash would feed 100 birds for four days, which means that 100 hens would need to lay only four eggs per day to cover the extra cost of the meatmeal. The difference between feeding a balanced ration and an unbalanced ration could easily mean a matter of dozens of eggs per day not just four. Naturally the greater the amount of locally manufactured meatmeal the farmer can obtain the better he will be financially, but nevertheless, from the above figures it will be seen that the farmer would be most unwise to feed his birds an unbalanced ration through his reluctance to pay £40 per ton for meatmeal to supplement that which is manufactured in Western Australia.

Unknown Vitamin-like Substance in Protein Rich Animal Foodstuffs.

Better growth in chickens and better hatchability of eggs have been found to accompany the feeding of rations which contain small amounts of animal foodstuffs, to chickens and breeding hens respectively.

Animal foodstuffs, through the essential amino acids which they contain, improve the biological efficiency of the ration, and part of the desirable response which results from such a practice can definitely be attributed to the amino acids. However, it is thought that only part of the desirable response can be explained when only the protein aspect is considered. In addition it is thought that an unknown vitamin-like substance occurs in feeding stuffs of animal origin, such as meatmeal and fishmeal and that this so called "X factor" is in large measure responsible for the increased growth and hatchability referred to above.

The importance of providing breeding fowls with a diet which contains sufficient animal concentrates is illustrated in figure 1, which is taken from Circular No. 788 of the United States Department of Agriculture. In this particular example fishmeal has been used to demonstrate the response obtained when an animal concentrate was fed. A similar response could be expected with meatmeal or other animal protein rich concentrates.

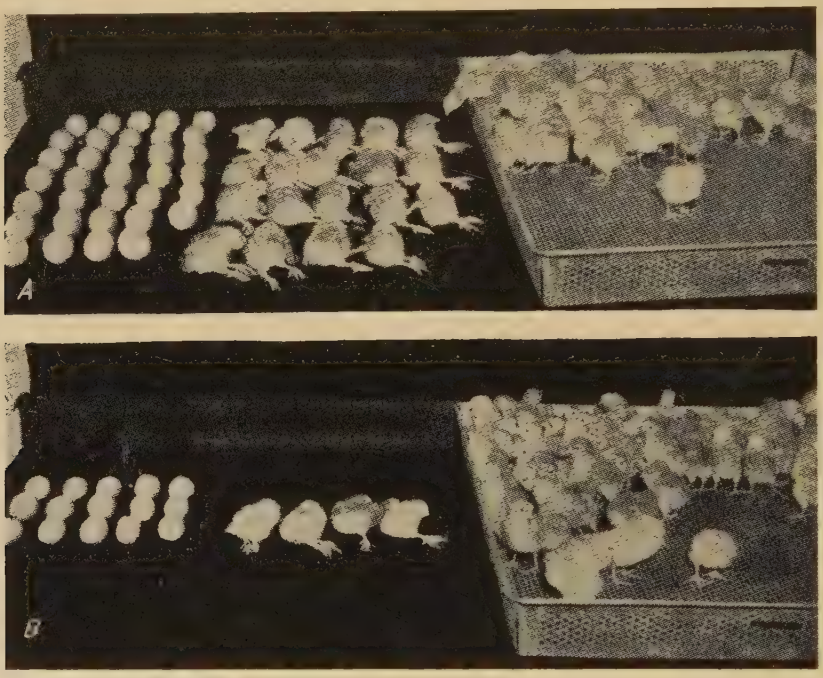


Fig. 1.

Effects of Properly and Inadequately Supplemented Vegetable Proteins.

A.—Of 100 eggs produced by hens receiving inadequately supplemented vegetable protein at a high level, 34 failed to hatch and 19 yielded chicks that died during the first week.

B.—Of 100 eggs laid by hens fed a similar diet supplemented with fish meal, 15 failed to hatch and 4 yielded chicks that died during the first week.

CARBOHYDRATES.

Carbohydrates consist of carbon, hydrogen and oxygen and are energy producing compounds. When fed in excess, carbohydrates are stored in the body in the form of fat. The feeding of excess carbohydrates is prevented by feeding the correct level of protein for the purpose required. If protein is lacking in the diet, young chicks will be slow to develop, hens will lay eggs at a sub-optimum level and will become excessively fat.

Carbohydrates vary greatly in chemical structure, ranging from simple water-soluble sugars, through starch, to the more complex, often indigestible, lignocelluloses which constitute the "crude fibre" fraction. This "crude fibre" is assumed to be indigestible by poultry.

Starches and sugar are broken down by digestive juices into simple sugars which are absorbed into the blood stream and serve as a source of energy for (a) movement, (b) maintaining correct body temperature, (c) supplying the vital body processes such as the beating of the heart and (d) the functioning of organs of respiration and the alimentary canal. Only after these requirements have been met can excess carbohydrate material be used for egg production or for fattening. Part of the excess carbohydrate is stored in the liver as glycogen. When required by the body the glycogen is reconverted to a simple sugar glucose which is used as a source of energy.

Examples of carbohydrate rich foods which are well utilised by poultry are wheat and maize grain, and pollard. High fibre-containing foodstuffs like mature greenfeed are poorly utilised. Between these two extremes are foods like oats and barley grain which, because of their fibre content, cannot be used at more than about 30 per cent. of the ration, but which can nevertheless be used at lower levels to advantage.

There is no possibility of Western Australian poultry rations being deficient in carbohydrates but the farmer should see that the intake of fibrous foods by his birds is not excessive.

The carbohydrate requirements of poultry have not been studied extensively chiefly because these food essentials are furnished in sufficient quantities in practical rations which contain all other nutritive essentials.

The chief sources of carbohydrates for poultry feeding are the common farm grains such as wheat and oats and the by-products of the flour milling industry, namely bran and pollard.

FIBRE.

Fibre only remains in the digestive tract for a short time and as the fowl's digestive juices are devoid of cellulose splitting enzymes, very little fibre is digested by the fowl; what little is digested is thought to be brought about by the enzymes contained in the food itself. While crude fibre can be digested to only an insignificant extent by poultry, it is generally recognised that a certain minimum amount is required in order to maintain optimum consistency in the alimentary canal content, thereby facilitating the action of the digestive enzymes on the other food nutrients. Some workers using oat fibre have placed this amount as high as eight to nine per cent. while others using wheaten bran as a source of fibre have obtained best results by restricting the amount of total fibre in the ration to about 4.5 per cent.

For best results with chicks and hens the ration should contain from five to eight per cent. of fibre in the dry matter. A ration which contains more than 10 per cent. of fibre may result in depression of growth and egg production due to the reduced digestibility of the carbohydrates in the food. Highly fibrous foods in addition to being indigestible are also unpalatable.

FATS.

The exact requirements of fat for poultry are not known, but it would appear that chick rations should contain from 4½-5 per cent. fat. As grains and mill offal vary in fat content from 2-4½ per cent. (approx.) and meatmeals from 10-20 per cent., practical rations which are balanced for other ingredients will automatically contain a reasonable level of fat. In one experiment 10 per cent. of fat in the form of soyabean oil was fed to chickens without any detrimental effect on growth, but when higher levels were fed the rate of growth was reduced. The

highest level fed in this experiment was 22 per cent. and at this level growth was retarded considerably and the chickens moulted frequently. Russell W. C., Taylor W., and Polskin L. J., (Fat requirements of the growing chick. Jour. Nutr. 19.555) and others have found that the fat requirement of the chick is quite low, finding no significant ill effects on the rate of growth when the diet contained only one tenth of 1 per cent., of fat.

The normal body temperature of the fowl is very high, (106.5°F—107.5°F) compared with mammals, and carbohydrates and fat are required to maintain this temperature. However, the body of the fowl is not built to utilise large quantities of fat, and the fat of the body is primarily derived from carbohydrate material (Buckner and colleagues 1941).

It is thought that the presence of a moderate amount of fat in the diet has a beneficial effect on calcium and phosphorus utilisation as these minerals need an acid reaction in the intestines for efficient absorption, and fat favours an acid reaction. The feeding of foods which contain excessive amounts of fat should however, be guarded against as such a practice will result in lowered utilisation of the other nutrients in the diet (proteins etc.). The fat forms a protective layer around the other nutrients which the digestive juices are unable to penetrate. In this way many undigested nutrients may be passed through the digestive tract and wasted. Rancid fats in particular should be avoided as these destroy vitamin E.

Before being absorbed into the fowl's system fats have first to be broken down by digestive enzymes into glycerine and fatty acids. These two components are absorbed separately and are reunited to form fat in the bird's body.

THE MINERAL REQUIREMENTS OF POULTRY.

Although no less than 15 different minerals are required by the fowl, it is seldom that special provision has to be made to include others than sodium, chlorine, phosphorus and calcium in the diet. Most practical rations which are composed of the generally recognised poultry feeding stuffs, and which are balanced from the point of view of other nutrients are, apart from the minerals mentioned, invariably well balanced from a mineral aspect. However, under special circumstances it is also possible for manganese to be deficient.

The other minerals essential to poultry but which are extremely unlikely to be deficient, and for which no special provision has to be made in the ration, are: magnesium, potassium, iron, zinc, cobalt, iodine, sulphur, and copper. These last named minerals are contained in feeding stuffs such as grains, mill offal, and meatmeal, in sufficient amounts to ensure a proper balance in any practical ration.

Calcium, Phosphorus and Manganese.

These three minerals will be treated together as the availability of each is in some measure determined by the amounts of the other two minerals present in the ration.

Calcium.

The calcium and phosphorus contents of rations for growing and laying stock are of considerable importance. Young stock fed calcium deficient rations show poor bone development, unthriftiness, and slow growth. Eggs laid by fowls on calcium-deficient rations have thin shells and low hatchability. A calcium deficiency will result in fewer eggs being laid. Excessive calcium feeding will also result in low egg production and lowered hatchability. With rations low in manganese a high level of calcium may result in the laying of soft shelled eggs, due to the bird's inability to utilise calcium in the absence of manganese.

The calcium requirements for the various classes of stock are fairly well known. Growing stock require one per cent. of calcium in their ration and laying fowls about 2.3 per cent. This latter figure can be increased to 2.5 per cent. for a flock that is laying particularly well, such as a flock at the height of production in the spring months.

Grains and their by-products contain very small amounts of calcium. See table 3. Meatmeals (particularly the low protein meatmeals) are relatively good sources, and materials like oyster shell, shell grit and ground limestone are very rich sources.

Table 3.

Ingredient.	Per cent. Calcium.	Per cent. Phosphorus.
Meat or fish meal—		
60 per cent. protein content	5.0	3.0
50 per cent. protein content	8.0	4.0
45 per cent. protein content	14.0	6.0
Bonemeal	20.0	12.0
Shellgrit	38.0	....
Oyster flour	38.0	....
Ground limestone	39.0	....
Wheat	0.04	0.22
Oats	0.05	0.22
Bran	0.07	0.60
Pollard	0.05	0.32

In order to meet a laying bird's requirements for calcium, it is necessary to include a percentage of a calcium-rich foodstuff such as oyster flour in the diet at all times, as a fowl can draw only enough calcium from its skeleton to make about four eggs. In the past it was usual to give the birds shell grit ad lib (finely ground for chickens) and the birds were relied on to eat the correct amount. There is a danger with this system, however, of the shell grit being unpalatable, and consequently sufficient may not be eaten. Because of the unreliability of this method and in view of our present knowledge which indicates that the calcium intake should be within certain well defined limits, there is a tendency on the part of poultry feeders to exercise a more rigid control over the calcium intake of their birds by feeding the required level of a calcium rich foodstuff, such as oyster flour in the mash.

The rations given in this article are balanced from a mineral aspect and do not require shell grit to be fed in addition. Birds should, however, have access to insoluble grit at all times. In general a chick mash does not require the addition of oyster flour to increase the calcium to the correct level. An all mash ration for laying hens requires 2½-3 per cent. and a mash for laying hens on a mash-grain system of feeding 3½-4½ per cent, providing the grain is not fed in excess of 1½ oz. per bird per day.

Phosphorus.

The phosphorus requirement of chickens is approximately 0.8 per cent. of the ration, and for a laying hen 1.0 per cent. Table 3 (above) shows bonemeal to be a rich source of phosphorus, meatmeal a good source and grains only a reasonable source. Practical rations of grains, mill offal, meatmeal and bonemeal contain sufficient phosphorus. Should it be desired to increase the phosphorus content of the ration as in the case of a ration which contains a high percentage of grain, this is most easily done by increasing the bonemeal in the ration.

The Calcium—Phosphorus Ratio.

Considerable work has been done with all types of farm animals to determine the ratio at which calcium and phosphorus should be fed. For chickens this ratio is approximately 1¼ : 1 and for laying hens 2¼ : 1.

The importance of this ratio is dependent on the fact that calcium and phosphorus are excreted in combination so that if there is an excess of calcium in the diet a heavy demand is made on the phosphorus in order that the excess calcium can be excreted. This results in a phosphorus deficiency although the phosphorus level in the diet may have been adequate had the calcium level been normal. In the same way an excess of phosphorus results in a calcium deficiency.

In practice, the excessive feeding of a high phosphorus-containing foodstuff like bonemeal to laying hens, is very liable to result in the laying of soft shelled eggs. The high phosphorus feeding decreases the calcium supply to such an extent that little calcium remains for egg shell formation. Hence, the importance of a correct calcium-phosphorus ratio.

Another example of a mineral imbalance which affects eggshell formation is the iron-phosphorus balance. The excessive feeding of iron results in phosphorus being excreted as iron phosphate. The increased egg shell strength that in sometimes claimed as a result of feeding an iron tonic to poultry could be the result of a tieing up of excess phosphorus in the food by the iron. Especially is this likely to happen if bonemeal has been fed in excess. The phosphorus of the bonemeal which would otherwise be combining with the available calcium prior to excretion is now being tied up by the iron and more calcium is therefore available for egg shell formation.

Before using tonics, the diet should be thoroughly checked to see that deficiencies or excesses of any nutrient do not exist. Provided poultry are fed balanced diets made from wholesome foods, tonics should not be necessary.

Manganese.

A low manganese, high calcium-high phosphorus will result in slipped tendons or perosis in chicks. The tendon slips from the hock, the hock swells and the leg turns out.

Choline and biotin (vitamins of the B complex) are also necessary in conjunction with manganese to prevent perosis, but these vitamins should not be deficient in Western Australian rations.

Half-a-pound of Manganese sulphate should be added to every five tons of mash (all mash diet) when a manganese deficiency is suspected. A high maize diet may be deficient in manganese but normal Western Australian rations should not be deficient in this mineral.

The conclusions reached by E. J. Underwood, T. J. Robinson and D. H. Curnow in their survey on the manganese content of foodstuffs used for poultry feeding in Western Australia were:—

> "(i) Where bran or pollard comprises a proportion of the daily "mash," rations composed of Western Australian grown feeding stuffs will normally provide ample manganese to meet all the requirements of growing or laying birds.

(ii) Where a system of "whole-grain" feeding is practised, the manganese intake will probably be adequate in most cases when wheat or oats or both constitute the bulk of the grain fed.

(iii) Where barley or maize or both constitute 50 per cent. or more of the ration, under a "whole-grain" system, it is considered advisable to provide a manganese supplement to avoid the possibility of manganese deficiency. A cheap and convenient means of doing this is to incorporate half per cent. finely ground manganese sulphate into the salt made available to the birds."

Fig. 2.
Chicken suffering from Perosis (slipped tendon).
By courtesy of Biester and Devries,
"Diseases of Poultry."

Sulphur.

Two of the "essential" amino acids namely cystine and methionine contain this mineral in sufficient amounts to ensure that sulphur is not deficient in a practical ration. There is, therefore, no need to feed free sulphur (flowers of sulphur). The inclusion of five per cent. or more of free sulphur in chick diets has resulted in chickens developing rickets and in their growth being retarded. Small amounts of sulphur in the diet have been reported to act as a partial preventative of coccidiosis. Sulphur cannot be recommended as a control of this disease, however, as something more than a partial preventative is required when combating coccidiosis. The recommended control of this disease is the inclusion of "sulphamezathine" in the drinking water. (Further particulars may be obtained from this Department.)

Magnesium.

Sufficient of this mineral is provided in practical rations and this element becomes important chiefly as one which should be avoided rather than one which should be added to the diet.

In growing chickens, a bone malformation similar to perosis is produced when excessive amounts of magnesium are fed. Dolomitic limestone should be avoided as a calcium supplement because of the magnesium contained therein. Excess magnesium prevents efficient utilisation of calcium. To prevent bone abnormalities and soft shelled eggs, never feed limestone which contains more than 3 per cent. of magnesium carbonate. Because of the possibility of limestone containing more than 3 per cent. of magnesium-carbonate, oyster flour is preferred to ground limestone as a calcium supplement.

WATER.

Water is one of the most important of the food essentials. Animals, including poultry, can live much longer without food than they can without water. Water is necessary for practically all body processes. Its main functions are :

1. To supply firmness and rigidity to the tissues.
2. To act as a solvent for food materials.
3. To transport food materials and waste products.
4. To manufacture body fluids including blood and lymph.
5. To regulate body temperature by evaporation of water from the respiratory tract.

In America White Leghorn hens have been shown to consume from 18.2 to 18.3 gallons of water per bird per year (approximately 5 gallons per 100 birds per day) and Rhode Island Reds 19.8 to 19.9 gallons per year (approximately 5½ gallons per 100 birds per day). Water consumption has been shown to increase with increases in atmospheric temperature, live weight and egg production. All poultry, and laying birds in particular must have an ample supply of fresh cool drinking water available at all times. Egg production can be stopped almost entirely in the course of 60 hours by taking away all water.

The drinking water may act as a medium for spreading many poultry diseases. Strict hygiene should therefore be applied to the watering system. In this connection the nipple watering system (refer this Dept's leaflet No. 940) has a lot to recommend it. The quantity of water consumed per bird per day will depend naturally on atmospheric temperatures. Generally speaking a fowl will drink twice as much water by weight as the food consumed.

It is useful to know the water intake of poultry of different ages, particularly chickens, as it is sometimes convenient to add drugs to drinking water to combat certain diseases, e.g., the use of sulphamezathine in combating coccidiosis.

WATER CONSUMPTION TABLE.

Age of Birds.	Approximate amount of Water consumed per 100 head per day.
Chickens—	
1–2 weeks	1 gallon
2–6 weeks	1½–2 gallons
6–10 weeks	3 gallons
10–20 weeks	4 gallons
Laying hens	5 –6 gallons

VITAMINS.

A number of poultry disorders can be attributed to vitamin deficiencies. Specific symptoms are not always shown by birds suffering from a particular deficiency, and symptoms can be very confusing, particularly if the deficiency is not acute. Where a vitamin is supplied at a level only just below that required by birds for normal health the birds may not show any marked symptoms, but one or more of the following conditions may be present in a mild form—retarded growth, poor feathering, decreased egg production or lowered hatchability. The farmer may not readily appreciate these mild symptoms as being the result of malnutrition and, therefore, it sometimes happens that the deficiency becomes acute and the symptoms much more striking and more typical of a particular disorder before steps are taken to rectify the condition. In connection with this, prevention through correct feeding, rather than "cure" is the policy adopted by most poultrymen. However, in spite of this there is reason to believe that the economic loss suffered each year by Western Australian producers through vitamin deficiency diseases in their stock is considerable. Of these deficiencies, Vitamin A deficiency in all classes of stock, and riboflavin deficiency in breeding hens, are perhaps the two most common. Vitamin D deficiency is also found in chickens that are deprived of sunlight.

VITAMIN A.

Functions of Vitamin A.

An adequate level of vitamin A in the diet is necessary to:—

1. Keep the bird in a healthy state. The mucous membranes which line the nose, mouth, gullet and eyes are particularly dependent on Vitamin A and in its absence these tissues lose their resistance to the disease organisms that are responsible for the various respiratory diseases of poultry. These diseases include coryza, laryngotracheitis, and chickenpox. Vitamin A deficient birds also show a greater susceptibility to worm infestation.
2. Ensure normal egg production.
3. Ensure that the Vitamin A content of eggs (normally 650 international units) is maintained. Eggs are a good source of Vitamin A in the human diet.
4. To allow good hatchability of eggs.

Results of Vitamin A Deficiency.

As with other vitamin deficiencies a partial Vitamin A deficiency is usually more common than a complete deficiency and symptoms may often be too mild to arouse suspicion. In this way considerable damage can be done before steps are taken to restore the situation.

In the case of a mild Vitamin A deficiency which might be brought about by poor quality greenfeed and fish oils, the only symptoms may be lowered egg production, poor hatchability, retarded growth and general unthriftiness, and these may not immediately be attributed to a Vitamin A deficiency.

Once the body reserves of the vitamin become exhausted and providing the vitamin intake is kept at a subnormal level more spectacular symptoms occur and it is only then that some farmers hasten to rectify the trouble. By then much damage has been done.

(Ewing: Poultry Nutrition.)

Fig. 3.

An advanced case of Vitamin A deficiency, showing the pharynx and esophagus studded with pustules.

Symptoms which accompany an acute deficiency are:—

1. Dejected appearance of the birds. The birds may show a staggering gait and a disinclination to move.
2. The formation of white, pin head size nodules or lesions dispersed over the mucous membrane lining the mouth, throat, oesophagus, (gullet) and nasal cleft, and the formation of a white film over the inside corners of the eyes.
3. Nasal discharge and the accumulation of white, cheesy, cankerous growths in the nasal cavities and mouth parts.
4. Swollen and discharging eyes with eyelids often stuck together, resulting in starvation of the birds with consequent loss of weight.
5. Degeneration of the eye tissues (xeropthalmia) and a clouding over of the cornea of the eye causing it to become opaque.
6. Distressed breathing because of the accumulation of cankerous material over the glottis.

Fig. 4.

(Ewing: Poultry Nutrition.)

Cheesy material in the eye of a fowl suffering from a Vitamin A deficiency. This condition is often shown by birds suffering from chicken pox, a fact which is somewhat confusing. However, wartlike lesions on the comb usually precede the "bung eye" condition of chicken pox. The nodules down the oesophagus which typify a Vitamin A deficiency are not present with chicken pox.

Fig. 5 *Government Photographer.*

Fig. 6

VITAMIN A DEFICIENCY.

Government Photographer.

Fig. 5 shows a White Leghorn hen to be suffering from a Vitamin A deficiency. The photograph was taken eight weeks from the time the bird was placed on a Vitamin A—deficient diet (one without green feed) at the Hollywood Laboratory. The bird has lost its sight and the discharge from the eye can be seen on the neck feathers. The open mouth suggests difficulty in breathing, and this is accounted for by the plug of caseous matter which can be seen blocking the glottis in Fig. 6.

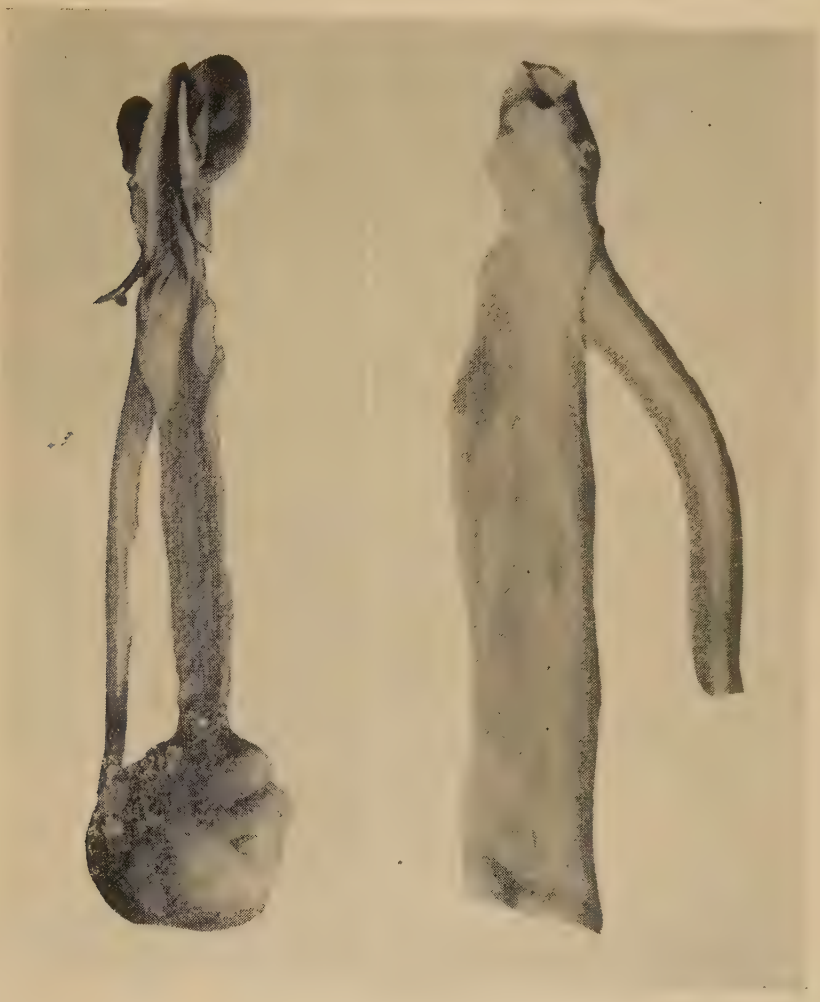


Fig. 7.

A. B.

Government Photographer.

Photograph A shows the œsophagus of the same bird (see Figs 5 and 6) slit open to expose the white pinhead size nodules which are characteristic of a Vitamin A deficiency. The nodules extend right down to the crop.

Photograph B shows an œsophagus from a bird not suffering from a deficiency of Vitamin A. There is no evidence of the white nodules in the oesophagus.

Death may be brought about by:—

1. Asphyxiation caused by the glottis being blocked with cheesy matter.
2. Kidney degeneration. On postmortem the kidneys and ureters (tubes leading from kidneys to cloaca) will be found to contain excessive amounts of cream coloured urates. A 40 per cent. increase in the uric acid content of the blood is not uncommon in fowls suffering from a Vitamin A deficiency.
3. Starvation through blindess.

Storage of Vitamin A.

Vitamin A deficiency symptoms are not noticed in birds immediately they are placed on a Vitamin A deficient ration. The time lag in this regard is due to the bird's ability to store Vitamin A in its body when on a Vitamin A sufficient diet. This reserve of the vitamin is used in the case of an emergency. The amount of Vitamin A stored by laying fowls on a Vitamin A-rich diet is sufficient to last them several weeks. Adult males can carry over for several months but chickens can only store enough to last them about three weeks. It is in growing stock that Vitamin A deficiency is most commonly seen.

Sources of Vitamin A.

Foods rich in Vitamin A are fish oils, livers, egg yolks, and whole milk. Young quickly growing succulent greens are rich in carotene, a precursor of Vitamin A.

To Cure Vitamin A Deficiency.

Having established the fact that the birds are suffering from a Vitamin A deficiency they should be given ample fresh leafy green-feed. A Vitamin A-containing oil at twice the strength recommended for preventing Avitaminosis A (See Table 4) should also be given for three or four days. The normal level of oil feeding can then be resorted to or discontinued entirely if ample good quality green-feed is available.

When green-feed is short, the farmer should resort to a fish oil of known Vitamin A potency and feed it at a level which will give his birds the desired Vitamin A intake (refer Table 4). If enough green-feed is available to provide one half of the birds' requirements for Vitamin A, the quantities of oil given in Table 4 can be reduced to one half.

Precautions to Adopt when using Fish Oils.

It should always be kept in mind that Vitamin A is a very unstable compound and is readily oxidised on contact with air. Because of this, batches of food which contain the oil should not be stored for longer than three days and should preferably be used immediately the oil is added, in order that the birds should derive maximum benefit from it. The presence of manganese supplements and charcoal in the mash, quickly destroys the potency of the oil.

Tins of oil should be kept in a cool dark place and the cap of the tin should be firmly screwed back into place following use.

It should be remembered that fish oils are not a complete substitute for green-feed. They provide Vitamin A and in some cases Vitamin D but they do not contain Vitamin G (riboflavin) and other vitamins which are esential to poultry and which are provided in green-feed, neither do they supply proteins and minerals which are to found in green-feed.

To ensure an even mix through the mash the appropriate quantity of oil (depending on its Vitamin A content) is usually thoroughly mixed with a small amount of bran or gristed oats, which is then uniformly sprinkled over the mash and incorporated by mixing. To ensure quick consumption of the oil the mash is usually fed wet, but little Vitamin A is lost from a dry mash providing the mash is not stored for more than three or four days.

The Vitamin A potency of fish oils is measured in international units per gram, and an oil which contains 2,000 international units per gram is naturally worth twice as much per gallon as one containing 1,000 international units per gram. When purchasing fish oils, the farmer should take into consideration their relative Vitamin A contents.

Vitamin D and Vitamin A are chemically and functionally different and the content of either in an oil has no relationship to the other. When buying an oil to prevent nutritional roup, (Vitamin A deficiency) only its Vitamin A content should be taken into consideration. The Vitamin D content of an oil is only significant when it is intended to prevent rickets (see Vitamin D deficiency).

The figures in Table 4 are based on the following Vitamin A requirements for the various classes of stock.

Chickens 2,000 Int. units of Vit. A. per lb. of food.
Laying hens 3,300 Int. units of Vit. A. per lb. of food.
Breeding hens 4,720 Int. units of Vit. A. per lb. of food.

TABLE 4.

Quantities of Oil required per 100 lbs. of Ration in the absence of green feed.

Potency of oil in international units per gram.	For chicks—		For layers—		For Breeders—	
	All mash ration.	Mash and grain ration.	All mash ration.	Mash and grain ration.*	All mash ration.	Mash and grain ration.*
	oz.	oz.	oz.	lb. oz.	lb. oz.	lb. oz.
800	9	13½	14½	1 7¼	1 4½	2 1
1,000	7	10½	11½	1 2½	1 0½	1 6½
1,500	4¾	7	7¾	0 12½	0 11	1 1½
2,000	3½	5¼	5¾	0 9¼	0 8½	0 13¼
2,500	3	4½	4¾	0 7½	0 6½	0 10½
3,000	2½	3¾	4	0 6½	0 5½	0 8¾
5,000	1½	2¼	2¼	0 3½	0 3¼	0 5¼

* A grain intake of 1½ oz. per bird per day is assumed.

Note.—One ounce equals two tablespoonsful approximately.

HOW TO DETERMINE THE AMOUNT OF VITAMIN A-CONTAINING OIL REQUIRED TO BE ADDED TO EACH 100 LB. OF A CHICK RATION IN THE ABSENCE OF GREEN FEED.

Assuming 1. Potency of oil to be 5,000 international units of Vitamin A per gram.

2. Amount of Vitamin A per lb. of food required by chicks to be 2,000 international units.

An oil with a potency of 5,000 international units of Vitamin A per gram contains 5,000 x 28.35 x 16 = 2,268,000 international units per lb.; there being 28.35 grams in one oz. and 16 ozs. in one pound.

The percentage of oil required in the total ration would be

$$\frac{2{,}000 \times 100}{2{,}268{,}000} = \frac{200{,}000}{2{,}268{,}000} = 0{\cdot}09\% \text{ which is approximately}$$

0.1 per cent., which means that in every 100 lb. of ration, 0.1 lb. or three tablespoonfuls of an oil with a Vitamin A potency of 5,000 international units per gram is required to ensure that the chicks receive a ration which contains 2,000 international units of Vitamin A per lb.

(0.1 lb. or 1/10 lb. = 1.6 oz. = 3 tablespoonsful as 1 tablespoonful is approximately ½ an ounce.)

Should the oil contain only 2,500 international units of Vitamin A per gram then 6 tablespoonfuls or 3 ozs. would be required to provide the same level of the vitamin.

In the same way the quantity of an oil which should be fed to laying hens can be determined. The Vitamin A requirement of laying hens is approximately half as much again as that required by young chicks.

Another and more direct method of determining the quantity of oil in ounces required to be added to each 100 lb. of mash on an all-mash system of feeding is as follows:—

Take the number of international units of Vitamin A per lb. required by chicks, laying or breeding hens and multiply by 100. Divide the result by the potency of the oil in international units per gram multiplied by the number of grams in one ounce. Taking a laying hen's requirements for Vitamin A to be 3,300 international units per lb. of food and using an oil which contains 800 international units of Vitamin A per gram, the amount of oil in ounces required to be added to 100 lb. of laying mash when the fowls are on an all-mash system of feeding would be:

$$\frac{3{,}300 \times 100}{800 \times 28{\cdot}35} = \frac{330{,}000}{22{,}680} = 14{\cdot}55 \text{ ozs.} \quad \text{(Refer Table 4.)}$$

VITAMIN D.

The anti-rachitic or rickets-preventing vitamin is unusual in that the bird's requirements for this vitamin can be met either through the diet or through the direct rays of sunlight. Two forms of the vitamin are known namely Vitamin D2 and Vitamin D3. Vitamin D2 is obtained by irradiating yeast and calciferol, and although effective for human beings and rats, is useless for fowls which require Vitamin D3.

Three sources of Vitamin D3 are available:—

1. Direct rays of sunlight.
2. Vitamin D rich fish oils (particularly liver oils).
3. Irradiated animal sterols.

Normally we rely on the sun's rays to provide our stock with sufficient Vitamin D. There occurs in the skin a pro-Vitamin D (called 7 Dehydro-cholesterol) which when acted upon by ultra violet light of the sun's rays, is converted into Vitamin D3 which the fowl utilizes. When fowls are deprived of access to the direct rays of sunlight (glass does not allow ultra violet light rays to pass through it) they must be provided with "ready made" Vitamin D rich materials, such as fish liver oils. The Vitamin D content of these oils varies a great deal as Table 5 shows:—

TABLE 5.

Type of Oil.	A.O.A.C. Chick Units per Gramme.
Cod Liver Oil	50 to 150
Shark Liver Oil	5 to 50
Sardine and Pilchard Liver Oil	100 to 400
Sardine Body Oil	15 to 80
Halibut Liver Oil	1,000 to 5,000

(Table from Nutritional Requirement of Poultry by G. L. McLymont. *N.S.W. Agricultural Gazette.*)

Although most fish oils supply both Vitamin D and Vitamin A it must be remembered that these two vitamins are in no way connected and the value of an oil in respect of a particular vitamin varies according to the relative amount of the required vitamin it contains.

Only oils of guaranteed Vitamin D content in A.O.A.C. chick units or international units by chick test should be purchased. An oil with 400 units per gramme is obviously worth twice as much per gallon as an oil with only 200 units per gramme.

Unlike Vitamin A, Vitamin D is not oxidised by the air, so that a Vitamin D containing oil can be mixed with feed and allowed to stand for a considerable length of time before using. If the mash contains milk products or mineral matter (e.g. bonemeal) or if the oil contains both Vitamins A and D, it is advisable to withhold the Vitamin D supplement until just prior to feeding. All oils should be evenly distributed throughout the mash.

The Vitamin D requirements of poultry (per lb. of feed) are:

Chicks .. .. 180 A.O.A.C. Chick units

Laying and Breeding Stock †450 A.O.A.C. Chick units

The following table indicates the amount of oils of different potencies which must be added to each 100 lb. of mash to supply adequate Vitamin D when birds are deprived of sunlight (1lb. of oil is approximately 1 pint.)

TABLE 6.

Potency of oil A.O.A.C. Chick units per gramme.	All Mash Ration for Chicks.	Grain and Mash Rations for Chicks.	All Mash Ration for Laying and Breeding Stock.	Grain and Mash Ration for Laying and Breeding Stock.
	ozs.	lb. ozs.	lb. ozs.	lb. ozs.
50	13	1 5	2 0	3 3
100	6½	0 10½	*1 0	1 9½
200	3	0 5	0 8	13
400	1½	0 2½	0 4	6½

* NOTE.—The amount of oil required is determined as follows:—

Vitamin D requirements of laying and breeding hens = 450 A.O.A.C. Chick units per lb. of feed.

An oil which contains 100 A.O.A.C. chick units per gramme contains 100 x 28·35 x 16 = 45,360 units per lb. Percentage of oil required in the ration =

$$\frac{450}{45{,}360} \times \frac{100}{1} = \frac{45{,}000}{45{,}360} = 1 \text{ per cent. approx.} = 1 \text{ lb. in every } 100 \text{ lb.}$$

† NOTE.—Some authorities claim that laying birds require only 360 A.O.A.C. chich units per lb. of feed. 450 units is however a safe level.

Top.—Australorp chicken three weeks of age showing Vitamin D deficiency. Note stunted growth, ruffled plumage, and malformed beak with food packed in the mouth. The beak of this chick was quite soft and this prevented the chick from eating properly.

Fig. 8. *Government Photographer.*

Centre and *lower* photographs show two six-week-old chickens suffering from rickets. Both have "gone in the legs," and the bones throughout the body were quite soft. The rough feathering of the lower chick is more typical of a Vitamin D deficiency. All chicks were intensively brooded in Western Australia in 1949 and deprived of sunlight. A few hours' direct sunlight would cure all three.

Therefore 1 lb. of oil should be added to each 100 lb. of mash if the birds are on an all-mash diet. If the birds are on a mash grain diet and 2½ ozs. of mash are eaten to every 1½ oz. of grain, then 1⅜ lb. of the oil ($1 \times \frac{8}{3} = 1\frac{3}{8}$) should be added to each 100 lb. of mash in order to obtain the same strength of the vitamin in the ration.

Vitamin D Deficiency.

(a) In Chicks.—A deficiency of Vitamin D results in the disease known as rickets. Rickets only occur where the deficiency is acute. Retarded growth is the first symptom noticed in chicks which are suffering from Vitamin D deficiency and only about half the level of Vitamin D required for maintaining maximum growth is required to prevent rickets.

If the deficiency is not remedied when slowed growth rates become evident, the gait becomes unsteady, the feathering ragged, and the chicks show a general unthriftiness and prefer to remain in a sitting position. Abnormal bone developments (swellings) may be detected in the legs (swollen hocks) and beading of the rib ends where they meet at the side of the breast bone may be apparent. Also the beak will become soft and deformed, the lower beak very often being much longer than the upper. Crooked breast bones can be the result of rickets but the breast bone is normally slow to calcify or harden, and too narrow perches will also cause crooked breast bones. Affected chicks may eat well but will die if the condition is not corrected. On post mortem the beak and leg bones will be found to bend easily. The leg bones will not snap like normal bones and an analysis would show them to have a very low mineral content.

Under West Australian conditions where chicks are normally allowed to run in direct sunlight when one week old a Vitamin D deficiency is not likely to occur. However, where chickens are confined in a brooder or brooder house and are

Fig. 9.
Rachitic bone indicating Vitamin D deficiency.
(Ewing—Poultry Nutrition.)

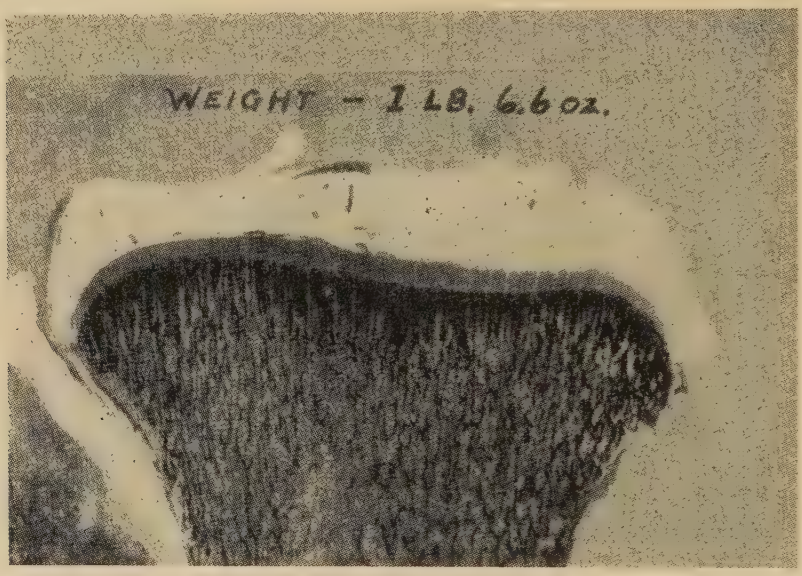


Fig. 10.
Normal bone showing good calcification.
(Ewing—Poultry Nutrition.)

deprived of receiving the direct rays of the sunlight, for more than 14 days (as they sometimes are with the Battery type of brooding system, or with any type of brooding system during inclement weather which necessitates the chicks being kept inside,) it would be advisable to include a Vitamin D rich fish oil in the diet.

Should an outbreak of rickets occur the possibility of an improper calcium phosphorus ratio in the diet as the cause should not be overlooked, and the ratio should be checked as described under the heading of Calcium-Phosphorus Ratio. By correcting the calcium-phosphorus ratio the outbreak may sometimes be controlled without providing extra Vitamin D.

(b) *In Adult Fowls.*—A deficiency of Vitamin D in adult fowls results in poorly shelled eggs, lowered egg production, and lowered hatchability. Rickets do not occur so readily in adult fowls as in chickens, as the bones have stopped growing.

Soft-shelled eggs is the first symptom noticed. Here again the calcium-phosphorus ratio should be checked. A Vitamin D deficiency would be unlikely under the popular system of semi-intensive housing that is adopted in this State. Intensively housed birds, however, should receive a Vitamin D-rich oil in their diet.

A high mortality in chick embryos between the 18th and 19th day of incubation may be the result of a Vitamin D deficiency. The inclusion of a Vitamin D-rich oil in the diet of breeders may be helpful in reducing this mortality, especially during extended periods of dull weather. An excess of Vitamin D in the diet may adversely affect egg-production, hatchability and even the health of the fowls. Care should therefore be exercised when adding Vitamin D-rich oils to rations. *Hens exposed to direct sunlight for 30 minutes per day during the winter months, and five to 10 minutes per day during the summer months receive sufficient Vitamin D3 for normal body functions and egg-production.*

VITAMINS OF THE B COMPLEX.

1. *Riboflavin.*

This vitamin plays an extremely important role in poultry nutrition and the magnitude of its importance has only of recent years been fully realised by many engaged in the Western Australian poultry industry. Numerous reports received from Western Australian producers indicate that the feeding of synthetic riboflavin or of natural foodstuffs which are rich in riboflavin (e.g. dried buttermilk powder) to breeding hens and to growing chicks has resulted in increased hatchability and increased growth rates to a marked degree.

A deficiency of riboflavin in the ration causes paralysis in chicks with a tendency to walk on the hocks, followed ultimately by a curling in of the toes. The growth is retarded because of poor feed utilization. In hens, a riboflavin deficiency results in lowered egg production, increased embryonic mortality and an increase in the size and fat content of the liver.

The riboflavin requirements of poultry as determined by Norris & co-workers (1936) are:

Chicks	290 gamma per 100 grammes food.
Breeding hens	230 gamma per 100 grammes food.
Laying hens	100 gamma per 100 grammes food.

(A gamma or microgramme is equal to 1/1,000,000th of a gramme.)

Excellent sources of riboflavin are dried brewers yeast, liver meal, lucerne meal, dried buttermilk powder, whey powder and synthetic riboflavin. Of these, dried buttermilk powder, whey powder and synthetic riboflavin are the three riboflavin-rich foodstuffs most widely used in Western Australia. In the absence of these three foodstuffs liquid skim milk can be fed with advantage to all classes of poultry, and to breeding hens and growing chicks in particular.

Rations for breeding hens and growing chicks must include riboflavin-rich foodstuffs, such as dried buttermilk powder or synthetic riboflavin if optimum results are to be obtained. Where dried buttermilk powder is used to supply riboflavin, chicks fed an all mash ration require four per cent. of buttermilk powder in their diet to ensure a satisfactory level of this vitamin. Breeding hens require 3½ lb. of buttermilk powder in every 100 lb. of mash if on an all mash system, and 5½ lb. in every 100 lb. of mash if on a mash-grain system (where grain is fed at the rate of 1½ ozs. per bird per day).

Rations for laying hens do not require the addition of ingredients which are noted for their high riboflavin content.

TABEL 7.

Relative Vitamin G (Riboflavin) content of common foods used in poultry rations (Norris and co-workers. 1936).

Foodstuff.	Units (gamma) of Vit. G. Per gramme of of feed.
Dried Pork Liver	100
Dried Yeast	35
Dried Whey	30
Dried Buttermilk	33
Dried Skimmilk	20
Liquid Skimmilk	2·2
Lucerne meal dehydrated	16
Meatmeal	6
Pollard and bran	2
Wheat	0·5
Oats	trace

Two photographs of the same chicken. That on the left was taken four days before that below. The photograph on the left shows the chicken from a Western Australian poultry farm to be suffering from "curl toe paralysis" brought about by a Riboflavin or Vitamin G deficiency. Following the taking of this photograph, the chick was fed for four days on a mash containing 6 per cent. of dried buttermilk powder. Fresh young lucerne tips were also given. At the end of four days the photograph below was taken and shows the chick to have regained the use of its legs, and with the toes almost straightened out. Within two weeks the toes were perfectly straight and the condition did not recur. Numerous cases of "curl toe paralysis" are reported to the Agricultural Department each year.

N.B.—Although this chicken received 6 per cent. of buttermilk powder in its ration, 4 per cent. is normally quite sufficient to provide the riboflavin requirements of chickens.

Fig. 11.

Government Photographer.

The requirement of chickens (see page 67) for riboflavin are much greater than for laying hens and curl toe paralysis is most commonly seen in chickens between the ages of three and 12 weeks, although chickens showing symptoms of riboflaving deficiency may be hatched from eggs laid by fowls fed a riboflavin deficient diet. Because of this, care should be taken to see that the riboflavin content of the ration fed to breeders is adequate.

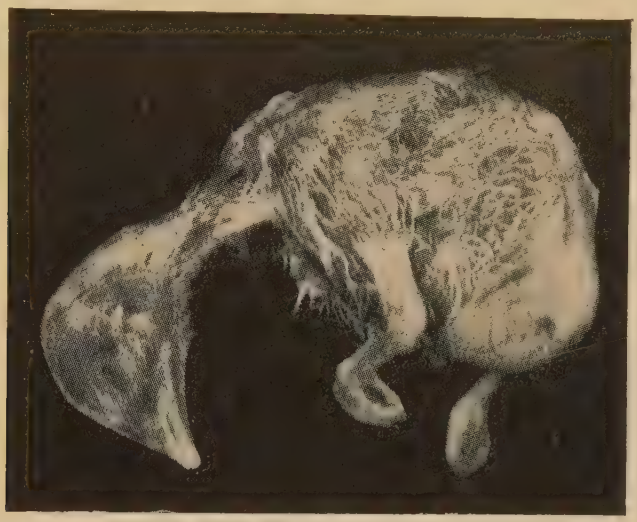


Fig. 12.
(Ewing—Poultry Nutrition.)
Twenty-one day dead embryo from an egg produced by a hen on a ration deficient in riboflavin, showing curled toes, incomplete yolk absorption, and poor down development.

Fig. 13.
(Ewing—Poultry Nutrition.)
Sciatic nerves excised from chicks on low riboflavin diets. A and A received added riboflavin. B neuromalacia chick.

2. *Vitamin B1 or Thiamine.*

This vitamin is necessary for maintaining the appetite, and the health of nervous tissue (prevents polyneuritis). Whole grains, wheaten by-products and green grass are excellent sources, so that Western Australian rations should not be deficient in this vitamin.

Pantothenic Acid. (Anti-dermatitis vitamin.)

A deficiency of this vitamin in the diet results in the formation of scabby lesions on the margins of the eyelids, at the corners of the mandibles and around the vent. However, this vitamin is most unlikely to be deficient in Australian rations as wheaten by-products are a good source of pantothenic acid.

Other vitamins which are essential in the diet but for which no special provision has to be made include: Vitamin K (anti-haemorrhagic vitamin), Vitamin C (anti-scurvy vitamin), Pyridoxine (Vitamin B6) Choline, Biotin, and the Anti-Gizzard erosion factor, (not yet identified chemically).

VITAMIN E.

A deficiency of this vitamin in chickens causes Encephalomalacia or Crazy Chick disease. Chickens affected with Encephalomalacia become droopy, their eyes are closed and the birds assume a fixed posture for long periods. There is a lack of power to co-ordinate muscular movements, head retraction, sometimes with lateral twisting and a rapid contraction and relaxation of the legs, followed by complete prostration and death.

The excessive feeding of fish oils may reduce the Vitamin E content of the ration to a level which is inadequate to meet the demands of chickens so that fish oils should not be fed at levels in excess of those recommended by the manufacturer. More particularly stale rancid oils should never be fed. Providing these precautions are taken Western Australian poultry should not suffer from a Vitamin E deficiency. Sprouted grains, wheat germ and greenfeed are excellent sources of Vitamin E.

Fig. 14.

Chicken showing symptoms of a Vitamin E deficiency.
From "Diseases of Poultry," by Biester and Devries.

BALANCE.

Fortunately fowls can make use of a wide variety of feeding stuffs and this allows flexibility in compounding rations. Nevertheless careful planning of the ration is necessary to see that all the food nutrients are supplied in proper amounts for efficient and economical production.

We must keep in mind that the hen invariably produces a complete egg and unless she can produce a complete egg then she will not produce one at all. Therefore, the quantity of eggs laid will be limited by the essential in the ration which is in the shortest supply.

The importance of feeding a balanced ration which contains a variety of feeding stuffs is appreciated if we take a particular foodstuff and consider its potential nutritive value from an egg producing point of view.

If wheat alone were fed, as far as the protein is concerned, a hen would be able to lay one egg every three days. The calcium in wheat would enable her to lay one egg every 12 days and the carbohydrate and fat content would enable her to lay three eggs every day.

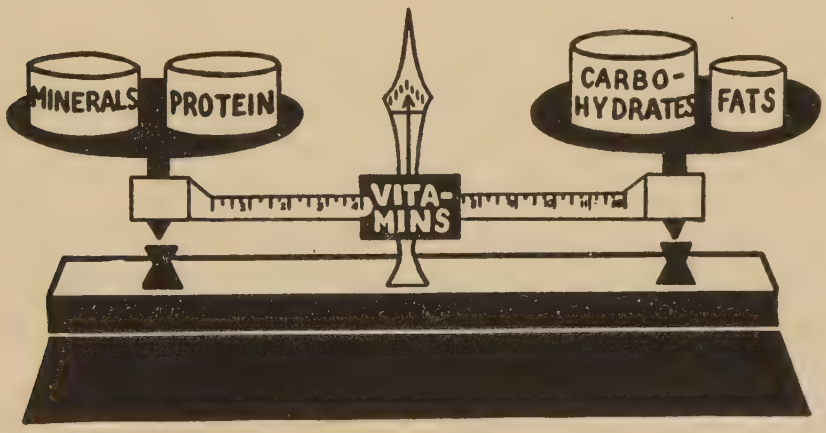


Fig. 15.

(Ewing—Poultry Nutrition.)

Even though the minerals, protein, carbohydrates and fats are contained in the ration in exactly the proper amounts, the egg production scale will not balance for maximum egg production until the final adjustment is made through the addition of the correct vitamins.

The importance of balance is further exemplified if we rate various foods in terms of potential yolks and whites which they can form.

Quisenberry estimated that 100 lb. of corn (maize) would be capable of producng 255 yolks and 134 whites. Corn is a "starchy" foodstuff. Its carbohydrate and fat content is much higher than its protein content. If corn alone were fed, enough yolk-building material would be used to make 134 eggs, since the protein is a limiting factor. The remainder of the fat and carbohydrate material would not be used for that purpose. Part of it might be stored as body fat but most of it would be wasted. On the other hand the same worker estimates that 100 lb. of meat scrap (meatmeal) contains enough carbohydrate and fat to form 106 yolks and enough protein to form 1,100 whites. Thus most of the protein could not be

used. Hence a balance is needed in order to get as nearly as we can, a combination of feeds which will supply a sufficient amount of these nutrients in the proper proportions, so that there will not be an excess of any one part which, in consequence, would be wasted.

A Balanced Ration.

In the broad sense of the term a balanced ration implies a ration which contains all of the essential food nutrients (proteins, carbohydrates, fats, vitamins and minerals), in the exact proportions which are required by fowls to perform with efficiency that function which we would have them perform, whether it be the laying of eggs, growth, or the laying on of fat. The nutritional requirements for the three functions given, vary considerably. It follows that a ration which is balanced for egg production is suitable only for that specific purpose, and one which is suitable for fattening cockerels is unsuited for producing eggs; that is, a ration which is balanced for either one of the three functions will be unbalanced from the point of view of the other two. If we want to get the best out of our birds, we should first determine their nutritional requirements for the particular work which they have in hand, and then make sure that their requirements are met by feeding an appropriate balanced ration to them.

Nutritive Ratio.

In a narrower sense a balanced ration implies a ration which has a correct protein-energy ratio or a correct nutritive ratio for the purpose required. The nutritive ratio is the ratio of the digestible protein to the digestible carbohydrates plus fat in any given foodstuff. It is derived by the following calculation:

$$\text{N.R.} = \frac{\text{Digestible carbohydrate} + (\text{digestible fat} \times 2.25)}{\text{Digestible protein.}}$$

From an energy point of view fats are approximately 2.25 times more valuable than carbohydrates, so that the digestible fat in a ration is multiplied by this figure and the product is added to the digestible carbohydrate to give the total energy value of a ration.

Protein is required to build those parts of the bird's body such as eggs, flesh, and feathers, which are rich in nitrogenous compounds, while carbohydrates and fats are used as a source of energy.

Although not strictly correct, crude nutrients instead of digestible nutrients are sometimes used in determining the nutritive ratio of a ration.

Using crude nutrients, most authorities agree that the nutritive ratio of a laying ration should be approximately one part of protein to 4.8 parts of energy producing foods, (carbohydrates and fats). A range of 1 : 4.5 to 1 : 5.0 is usually allowed.

In determining the nutritive ratio the vitamins and minerals which occur in a practical ration in small amounts only, but which are nevertheless essential, are ignored. Because of this and because there are no Australian digestible nutrient figures available for poultry, the writer prefers not to use the nutritive ratio method in determining the balance of a ration.

The present day tendency is to use the protein content of rations as a basis for determining their suitability for feeding to the various classes of poultry. This method is favoured because of its simplicity and is just as effective as the nutritive ratio method.

Although protein is the main consideration in determining the suitability of any ration, its mineral content (calcium and phosphorus in particular) is also

important, especially as the modern tendency is to provide the bird's calcium requirements through oyster flour in the mash rather than through shell-grit.

The fibre and fat content of the ration must not be excessive for reasons given elsewhere in this article and this aspect should also be considered when assessing the worth of a ration.

The Effect of Feeding an Unbalanced Ration.

A ration containing a large proportion of protein to carbohydrate is said to be narrow. The feeding of excessively high protein rations is not economical as rich protein foods are costly. Incomplete digestion would follow such a practice and the birds would suffer from digestive troubles. If long continued the kidneys would become over-taxed in an attempt to excrete the waste nitrogen (uric acid.) Through inefficient elimination of the uric acid, uric acid poisoning would result.

On the other hand a ration which contains only a small amount of protein is said to be "wide." Through difficulty in obtaining protein concentrates at the present time the farmer is more likely to be concerned about the danger of feeding a ration which is too wide, rather than one which is too narrow.

Growth of young animals is mainly a matter of muscle increase. The protein content of muscle is high and if carbohydrate-rich foods (grain and their by-products) were fed in excess to chickens, their growth would be slow. Part of the excess carbohydrates would be stored as fat (this we attempt to do when finishing young stock for market) but this process could not go on indefinitely and most of the excess carbohydrates would be wasted. In laying birds, egg-production would decrease because of insufficient protein to form the albumin or "whites" of the eggs. The birds would become over-fat and we would then expect disease and internal haemorrhages to become frequent. Also the birds would have difficulty in laying and would tend to lay ridged and misshapen eggs.

Factors to consider in the balancing of a ration and which determine its practicability are:

(a) Chemical composition of the ration.
(b) Palatability.
(c) Digestibility or availability of the nutrients.
(d) Mechanical effect.
(e) Medicinal properties.
(f, g, and h) Variety, availability and costs of components.

Chemical Composition.

Before we can confidently make changes in our feeding, it is necessary that we know the composition of the various feeding stuffs, and be appreciative of the functions which each performs. The following table should be of particular interest to the Western Australian producer as it contains crude protein figures for average samples of Western Australian feeding stuffs.

A comparison of some of the figures from this table with similar figures for the same foodstuffs grown in other parts of the world and in the Eastern States of Australia show how important it is for the farmer when compounding a balanced ration, to know fairly accurately the nutritive values of the feeding materials he has at his disposal.

Comparing figures for protein of Western Australian foodstuffs with those of the same foodstuffs grown in the Eastern States one can generalise by saying that the Western Australian foodstuffs are on an average lower in protein. Typical protein values given for N.S.W. foodstuffs are bran 15 per cent., pollard 15 per cent., wheat 12 per cent., oats 11 per cent., meatmeal 60 per cent.

Table 8.

ANALYSIS OF WESTERN AUSTRALIAN FOODSTUFFS.

	Per cent Crude Protein.	Per cent. Calcium.	Per cent. Phosphorus.
Wheat—F.A.Q.	10	·04	·22
Oat grain	9	·05	·22
Barley—feed	10	·04	·22
Field peas	22	·06	·38
Blue lupins	32	·15	·37
Tangier peas	36	·12	·44
Wheat bran	14	·07	·60
Wheat pollard	13·5	·05	·32
Meatmeal	35–50	8·0	4·0
Bonemeal	18–22	20·0	12·0
Skimmilk	3·7	·13	·11
Dried buttermilk	30–35	1·3	0·8
Whey powder	12·5	1·2	0·66
Oyster Flour	....	38·0	....

The relatively low protein content of Western Australian cereal grains places the West Australian producer in a less favourable position than the Eastern States producer, as in order to feed his fowls levels of protein associated with balanced rations, the Western Australian producer has to make greater use of the expensive protein concentrates such as meatmeal, fishmeal, liver meal and dried butter-milk powder.

Palatability.

The palatability of a foodstuff is of great importance in determining its place in a ration, as even a slight reduction in feed consumption results in slower growth or reduced egg production.

Digestibility and Availability of the Nutrients.

This applies particularly to protein-rich foods Two foods may have the same "crude" protein content but the percentage of "available" or "digestible" protein may vary.

Mechanical Effect. (Feed Texture.)

The so called texture of a feed mixture is important. Too open a texture will be found in a mash which contains too much fibre and which is invariably low in protein. English authorities in particular, place importance on the cubic capacity test of a mash as a guide to its suitability as a foodstuff, and in bulletin No. 7 by the Ministry of Agriculture and Fisheries, it is claimed that mashes having a cubic capacity of more than 70 cubic centimetres per oz. may be regarded as too bulky where maximum production is required. In measuring bulkiness 1 oz. of the mash is placed in a 100 cubic-centimetre glass measuring cylinder and the sides tapped with the fingers so as to cause the particles of the mash to come into a position of rest, in contact with one another. As a guide, the dry mash fed to the Trial birds at Muresk (see Page 76) has a cubic capacity of 58 cubic centimetres per oz.

Very fine mashes which contain a very high percentage of materials such as pollard or finely gristed wheat or oats are likely to be unpalatable as the mash "balls" on wetting and a sticky mass is likely to form in the mouth.

Chickens in particular have difficulty in swallowing very fine mashes and accumulations of fine mash in the corners of chickens' mouths, in their nasal cleft and on their toes is frequently seen. A granular, loose textured mixture of feeding stuffs is nearly always palatable and therefore to be preferred.

Medicinal Properties.

Certain foodstuffs when fed in excess will have a laxative effect on the birds, e.g. the feeding of linseed meal above a 4 per cent. level. Other materials although beneficial in small amounts will have a toxic effect if fed in excess e.g. salt.

Some greenfeeds when fed in excess to hens will cause undesirable effects in the eggs laid e.g. field pennycress, shepherd's purse and rape have been known to produce olive coloured yolks, while marshmallow and cotton seed meal (the latter above 5 per cent of the diet) have produced "pink whites" in eggs. Linseed meal fed in excess will also give a greenish tinge to yolks.

Variety, Availability and Cost of Components.

A variety of feeding stuffs is required to provide the complete range of nutrients necessary for the various bodily functions.

The supply of a selected foodstuff should be adequate to meet the demand, as marked changes in feeding over short periods (particularly laying hens) which could result from inadequate supplies of any one foodstuff, can have extremely serious results.

The price must be low enough to enable the farmer to feed his fowls economically. The aim is to supply all the necessary nutritive elements in adequate amounts and as cheaply as possible. Sometimes it is possible to substitute one foodstuff for another, but often two or more foodstuffs are required to replace one foodstuff in a ration.

In order to demonstrate how a laying hen's diet is balanced, the balanced rations fed to the trial birds at Muresk College are given below.

FEEDING OF THE EGG LAYING TRIAL BIRDS AT MURESK.

Wet Mash, Dry Mash, Grain System.

Wet Mash Fed to all Birds at the rate of one kerosene-tinful to each 80 birds. This is equivalent to 2 ozs. of dry material to each bird. Two fifths of the wet mash by bulk consists of finely cut greens.

Ingredient.	lb.	Protein.	Calcium.	Phosphorus.
Bran	10	1·4	0·007	0·06
Meatmeal	5	2·5	0·4	0·2
Bonemeal	1½	0·33	0·3	0·18
Pollard	10	1·35	0·005	0·032
Wheatmeal	9	0·9	0·003	0·02
Oyster Flour	2	....	0·8	....
	37½	6·48	1·515	0·492
	100	17·3	4·0	1·3

This wet mash contains 13.3% Meatmeal.

Dry Mash for R.I.R.'s. Available in dry mash hoppers at all times.

Ingredient.	lb.	Protein.	Calcium.	Phosphorus.
Bran	30	4·2	0·02	0·18
Meatmeal	22	11·0	1·76	0·88
Bonemeal	4½	1·0	0·9	0·54
Wheatmeal	56	5·6	0·022	0·12
	112½	21·8	2·702	1·72
	100	19·4	2·4	1·5

In the dry mash the White Leghorns receive 18 lb. of meatmeal in every 108½ lb. of mash and the Australorps 26 lb. of meatmeal in every 116½ lb. of mash. The White Leghorns therefore receive a dry mash containing 18.2% crude protein and the Australorps one containing 20.4% crude protein.

Percentages of Meatmeal in the respective Dry Mashes.

White Leghorns	16.6%
R.I.R.'s	19.6%
Austs.	22.3%

Assuming a daily food consumption per bird per day of

Wet Mash	2 ounces
Dry Mash	1 ounce
Wheat (grain)	1½ ounces

the respective breeds receive the following percentages of total crude protein, calcium and phosphorus in their diet.

———	Per cent. Protein.	Per cent. Calcium.	Per cent. Phosphorus.
White Leghorns	15·1	2·28	0·96
R.I.R.'s and Langshans	15·3	2·3	0·98
Australorps	15·5	2·37	1·0

Explanation.

Taking the wet mash which is fed to the trial birds as an example, the following method is used to determine the percentages of protein, calcium and phosphorus that a mash contains.

Taking the first ingredient, bran, it will be seen from Table 8 on page 74 that bran contains 14 per cent. crude protein, 0.07 per cent calcium and 0.60 per cent. phosphorus.

The amount of protein in 10 lb. of bran is therefore:—

$$\frac{10 \times 14}{100} = 1{\cdot}4 \text{ lb.}$$

Similarly the amounts of calcium and phosphorus in 10 lb. of bran are:—

$$\frac{10 \times 0{\cdot}07}{100} = \frac{0{\cdot}7}{100} = \frac{0{\cdot}007}{1} = 0{\cdot}007 \text{ lb.}$$

and

$$\frac{10 \times 0{\cdot}60}{100} = \frac{6}{100} = \frac{{\cdot}06}{1} = 0{\cdot}06 \text{ lb.}$$

respectively.

Similarly, by taking the weights of the various ingredients and using the figures given in Table 8 the amounts of protein, calcium and phosphorus contained in the weights of the various ingredients used, can be determined.

Adding the weights of the ingredients used, also the weights of protein, calcium and phosphorus it will be seen that 37½ lb. of food contributes 6.48 lb. of protein, 1.5 lb. of calcium and 0.49 lb. phosphorus. Therefore 100 lb. of the ration contains 17.3 lb. of protein, 4.0 lbs. of calcium and 1.3 lbs. of phosphorus.

Dry Mash.

Using the same method it can be shown that 100 lb. of the dry mash which is fed to the Rhode Island Red pullets contains 19.4 lb of protein, 2.4 lb. of calcium, and 1.5 lb. of phosphorus.

Wheat.

Table 8 shows 100 lb. of wheat to contain 10 lb. of protein, 0.04 lb. of calcium and 0.22 lb. of phosphorus.

Balance.

The birds entered in the trials are on the average high producers and the amount of food consumed per bird per day has been shown to be approximately 4½ ozs. rather than 4 ozs. which is the amount consumed per day by an average flock of farm birds.

The 4½ oz. consists of—

Wet Mash	2 ounces
Dry Mash	1 ounce
Grain (wheat)	1½ ounces

which means that for every 100 lb. of dry mash consumed; 200 lb. of wet mash and 150 lb. of wheat are also eaten. The percentages of crude protein, calcium and phosphorus contained in the diet (total food intake) of the Rhode Island Reds, is as follows.

Protein.

Wet mash	=	17·3 lb.	×	2	=	34·6 lb. in 200 lb.
Dry mash	=	19·4 lb.	×	1	=	19·4 lb. in 100 lb.
Wheat	=	10·0 lb.	×	1½	=	15·0 lb. in 150 lb.
Total						69·0 lb. in 450 lb.

$$\frac{69{\cdot}0 \times 100}{450} = \frac{6900}{450} = 15{\cdot}3 \text{ lb. in } 100 \text{ lb.}$$

= 15·3 per cent.

Calcium.

Wet mash	....	4·0	×	2	=	8·0 lb. in 100 lb.
Dry mash	....	2·4	×	1	=	2·4 lb. in 100 lb.
Wheat	....	0·04	×	1½	=	0·06 lb. in 150 lb.
Total						10·46 450

$$\frac{10{\cdot}46 \times 100}{450} = \frac{1046}{450} = 2{\cdot}3 \text{ lb. in } 100 \text{ lb.}$$

= 2·3 per cent.

Phosphorus.

Wet mash	....1·3	×	2	=	2·6 lb. in 200 lb.
Dry mash	....1·5	×	1	=	1·5 lb. in 100 lb.
Wheat	....0·22	×	1½	=	0·33 lb. in 150 lb.
Total	....	....	....		4·43 450

$$\frac{4{\cdot}43 \times 100}{450} = \frac{443}{450} = 0{\cdot}98 \text{ lb. in } 100 \text{ lb.}$$

= 0·98 per cent.

The percentages of crude protein, calcium and phosphorus in the diets of the white Leghorns and Australorps can be worked out in a similar manner.

The trial birds receive three quarters of a kerosene-tinful (6 lb.) of finely cut greens per 100 birds per day as an evening feed. Greenfeed is also fed at the rate of one half a kerosene-tinful (4 lb.) per 100 birds per morning in the wet mash, making a total daily intake of 10 lb. of finely cut greens per 100 birds per day.

SYSTEMS OF POULTRY FEEDING.

A number of systems have been used with success. A great deal of experimental work has been carried out in an attempt to determine the best method of feeding, but the general consensus of opinion is that there is no best method. The method adopted is determined largely by outside circumstances such as the cost and availability of the different foodstuffs (grain, mill offal, etc.), and the amount of labour, time and feeding facilities available to the farmer. Titus in his "Scientific Feeding of Chickens" (1941) summarises the position by writing "It is more important to supply chickens (covering fowls of all ages) with adequate quantities of all the necessary nutrients than it is to follow a given system. Any system that insures, through design or by accident an adequate supply of all the essential nutrients is sure to be successful from the standpoint of nutrition."

Methods of Feeding.

The following methods are usually regarded as a basis for economical balanced feeding.

1. Wet mash—dry mash—grain system.
2. All dry mash system.
3. Free choice system.
4. Dry Mash—Grain system.
5. Wet mash—Grain system.
6. Pellets.
7. Soaked grain feeding.

Wet Mash-Dry Mash-Grain System.

This system was until recent years practically the only one used in Western Australia. It is still popular although other methods (in particular the all-mash system) are being used more and more each year.

One feed of wet mash is given in the morning. Dry mash is before the birds all day, and a feed of grain is given at night. The grain may be straight grain e.g. wheat, or a mixture of grains, e.g. wheat and oats. The high-producing hens eat large quantities of the dry mash, and the poor producers hardly any. The amount of grain fed must be known in order to add sufficient proteins and minerals to the mash to balance the diet.

Wet Mash.

Advantages claimed by advocates of wet mash feeding are:—

1. The wetting of some mashes (particularly dusty mashes) makes them more palatable, and increased food consumption automatically follows. This results in greater egg production. However most experiments have been unable to prove the superiority of wet mashes over dry mashes. A few more eggs may be laid by birds fed on wet mash, but the time and labour involved in mixing and distributing the wet mash can usually be shown to offset this.

2. Wet mash feeding lends itself to efficient administration of medicines, the most important of them being Black Leaf 40 for worms. Fish oils also are conveniently incorporated in a wet mash. The rapidity with which a wet mash is consumed ensures that little of the vitamin potency of the oil is lost through oxidation.

Mixing Wet Mash.

From a palatability point of view, it is desirable that the wet mash should be fed in a crumbly condition. When squeezed in the hand it should stick together in a lump. When the lump is placed on a flat surface and knocked with the hand it should fall apart. In order to obtain this consistency, it is, of course, necessary to add the exact amount of water required. Also, where the mash is mixed by hand the order in which the mixing is carried out will be found to help in obtaining this consistency. The recommended procedure is as follows:

Place greenfeed, bran, meatmeal, bonemeal, oyster flour and salt if any, in the trough. Mix these ingredients well. Add required amount of water. Mix again. Add pollard and wheatmeal and mix thoroughly until all materials are wetted and the desired consistency is obtained. If the mash contains too much fine material e.g. too much pollard or finely ground wheat, a sticky, doughy mash will result. Bran and coarsely ground grains will assist in keeping the mash open.

When using a power driven mixer, the greenfeed and all the dry ingredients can be placed in the mixer at the one time. These are thoroughly mixed, the water is added and the whole mixed again.

All Dry Mash System.

This system is becoming increasingly popular in Western Australia and indeed throughout Australia, and is the method which appeals to the writer most. Dry mash is placed in self feeders which hold several day's supplies, and the birds have access to the hoppers at all times. Whole grain is not fed, but a tightly packed kerosene tin full of finely chaffed succulent greens should be fed to each 100 laying hens each evening.

The self-feeder should be constructed so as to avoid waste; a lip (one inch wide) around the edge of the tray together with the use of a coiled piece of wire as outlined in the caption for Fig. 16B, will assist in this direction.

The feeding of dry mash in self feeders is recommended to farmers who have limited time at their disposal. A suitable hopper can be constructed from a 44-gallon drum. A hopper of this size will be sufficient for 35 hens. With dry mash feeding it is important to see that the mash is free flowing and that it is available to the birds in adequate amounts throughout the day. Temporary starvation through inefficient working of hoppers will result in lowered egg production, particularly with pullets just coming in to the lay.

Dry mash hoppers should be placed in the shade and in the summer months the fowls should not have to travel over a stretch of hot ground to get from the self feeder to the drinking water. The water should be reasonably close to the dry mash feeder.

Advantages of Feeding Dry Mash.

1. The system ensures that all birds obtain a balanced ration throughout the day. It is very common to see a poultry farmer feeding a correctly balanced mash and then unbalancing the ration by the indiscreet feeding of grains.

2. The system ensures better and more uniform growth in the flock, as the timid as well as the aggressive birds get a chance to eat a mash containing the necessary ingredients for optimum growth.

3. It is more sanitary than the scratch feeding of grain.

4. The system is simple for there is less labour and skill required in feeding.

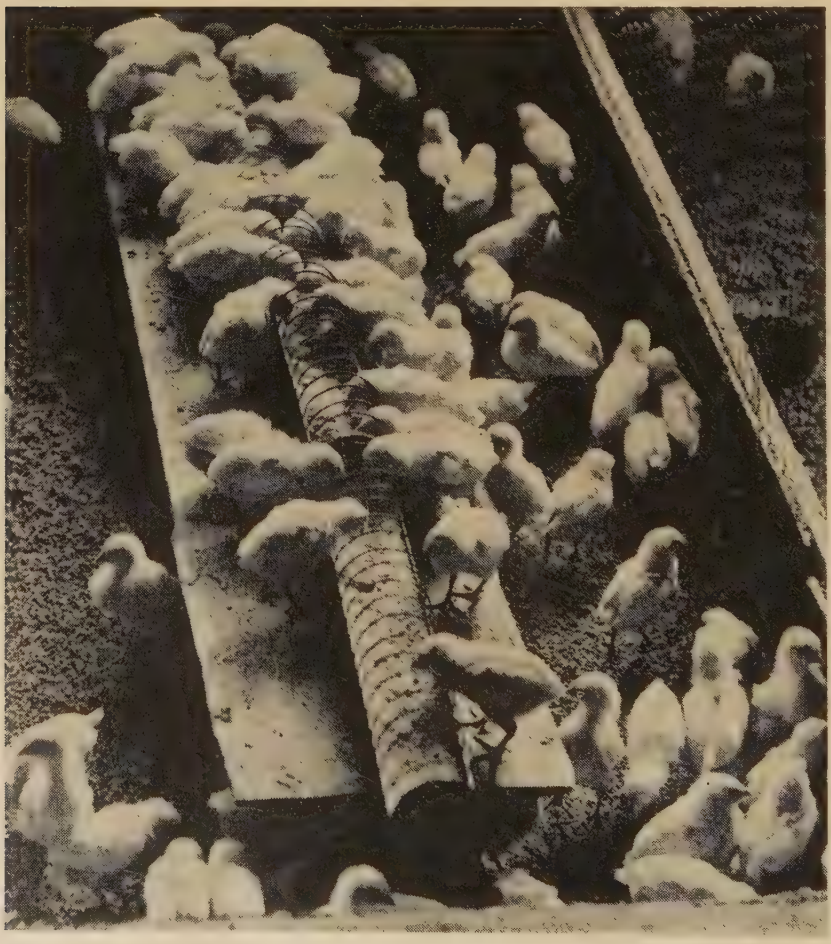


Fig. 16A.

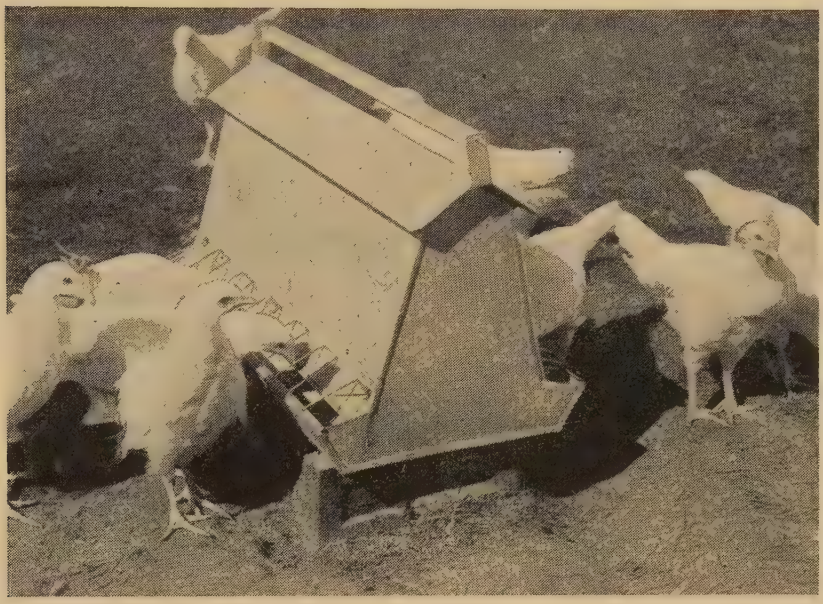


Fig. 16B.
By courtesy of the "Weekly Times," Melbourne.

The All-Dry Mash System of feeding poultry is rapidly replacing other methods of feeding throughout Australia. This method is recommended by the Western Australian Department of Agriculture. To be successful the stock should be reared on dry-mash right from day old. Also, the Dry-Mash Feeder or Hopper should be so constructed as to prevent waste.

These two photographs illustrate ways in which the latter requirement can be achieved.

Photograph (A) shows three-week-old chicks eating from a dry-mash-hopper. The wire prevents the chickens from entering the trough and scratching in the mash. The hopper is raised on a platform to prevent the litter from fouling the mash. This type of hopper would not be suitable for chicks younger than three weeks of age, as very small chicks may become jammed between the wire and the mash.

Photograph (B) shows a type of hopper suitable for growing stock. Note the wire which together with the lip on the trough prevents waste, also the fact that the hopper is raised from the ground. The revolving anti-perching device on the top of the hopper is quite effective.

Many Western Australian producers have overcome wastage in the circular, drum type, Dry-Mash-Feeder, by coiling a piece of 8 or 10 gauge wire round a length of piping (2 in. diameter) to form a spring, the coils being sufficiently wide to allow the birds to feed. The spring is then placed round the trough of the hopper, so that about one half of the spring shows above the mash. This together with the aid of a lip on the trough, which is usually one inch wide, prevents the birds from scooping out the mash.

Disadvantages.

1. It may be slightly more expensive as ground grains are slightly more expensive than whole grains and ground grains should be included in a mash to ensure a good texture.

2. Suitably constructed waste-preventing hoppers with adequate feeding space are essential.

Herein lies the secret of success with the all mash system of feeding. If the birds have to fight for their food poor results will be obtained.

The following lengths of hopper space should be allowed stock of different ages:—

1- 4 weeks	6 feet per 100
4-10 weeks	12-14 feet per 100
10-20 weeks	16-20 feet per 100
Mature	24 feet per 100

The term "hopper space" refers to the effective feeding space; thus a 4 ft. double sided hopper gives 8 ft. of hopper space.

Growth and production will be aided if the surface of the dry mash is raked over every time the attendant goes into the shed as the birds like to pick at a freshly exposed surface of the mash.

To obtain high production from laying hens on a dry mash system of feeding, the mash must have a high degree of palatability. This demands a relatively "open" mash. When large quantities of a properly balanced mash are eaten, the birds cannot help but lay eggs in large numbers. For best results, and this is important, the hens should know nothing else than a dry mash system of feeding, i.e. they should be reared on dry mash from day old. The feeding of wet mash may result in a few more eggs being laid, but the time and labour saved when a dry mash system is employed more than compensates for the few eggs that may be lost. The farmer receives no thanks for any unnecessary work in which he indulges. Should it be desired to treat the flock for worms with Black Leaf 40, a wet mash can always be fed for a few days, and discontinued as soon as the dosing is complete.

Free Choice System.

With this system usually two hoppers are provided. One hopper containing whole grain or mixed whole grains and one containing meatmeal or a mixture of protein concentrates.

This system has proved satisfactory in a number of instances and its greatest use in this State possibly lies in the wheat and oat belt areas, where such a system would keep purchased foods to a minimum. Evidence from N.S.W. and preliminary work at Muresk, suggest that this system of feeding may encourage feather picking. However, if birds were on an open range or had a large running space this vice should not occur. Wheat grain is most suited for this type of feeding and Victorian experiments indicated that wheat in one hopper and straight meatmeal in another, gave satisfactory egg production compared with standard wet and dry mash-grain rations.

If the free choice feeding system is to be used it is most advisable to break the growing chicks into this type of feeding when they are approximately three months old. Laying hens that have been on a mash grain system are unlikely to take kindly to a change in feeding of this nature. All mash or mash-grain rations are more suitable for breeding hens because the requirements of breeding hens for riboflavin in particular and for some other nutrients in general are greater and more exacting than for laying hens. These latter methods of feeding allow more control to be exercised over the nutrient intake of the birds and this is necessary if good uniform hatching results are to be obtained.

Feeding tests carried out at the Victorian State Government Experimental Farm—Werribee—showed that satisfactory egg production could be obtained by feeding whole grains and meatmeal ad lib., providing sufficient meatmeal was

eaten by the birds. Some meatmeals are unpalatable and meatmeals containing 60 per cent., protein should be used with this system of feeding, as the higher protein meatmeals are the most palatable. A mixure of grain was found more satisfactory than wheat alone. In the Victorian experiments the grain mixture that gave the best results consisted of wheat four parts, oats, barley, and maize each one part (by weight).

Dry Mash and Grain System.

Dry mash is placed in hoppers to which the birds have access at all times and grain is placed in another hopper which is opened during the late afternoon, or grain may be fed by hand. A high protein mash is required to balance the low protein grain.

Wet Mash and Grain System.

This method of feeding was adopted by many Western Australian poultry farmers in years gone by, but the weaknesses of the system were gradually discovered, with a consequent swing by the industry to other, more satisfactory methods. It was the custom in this State for many years to feed laying hens a wet mash in the morning and grain at night, without any provision for dry mash. This meant that the hens were without food for many hours in the middle of the day. A good bird's natural reaction to abuse of this kind is to lay fewer eggs as a high-producing hen requires free access to food throughout the day. Many high producing hens lay early in the day and if the feeding of the wet mash is carried out while these birds are on the nest, then they simply go without their morning mash, and have the scraps that are left by the rest of the flock. This results in these good birds eating more grain than they should at night, and consequently laying fewer eggs.

This system is sometimes used in feeding chicks. The mash is mixed with water or milk. Several wet mashes are given to the chickens during the day, and grain is fed to them at night. However, dry mash feeding is preferable as it is much less laborious.

Pellets.

Pellets are simply compressed mash. Pellet feeding eliminates waste, but pellets are more expensive than the same ingredients in mash form.

Soaked Grain Feeding.

This is not usually considered superior to dry grain feeding.

The soaking of grain for 12 to 24 hours results in only a small amount of the starch in the grain being converted into sugar. The feeding of soaked grain with meatmeal and skim or whole milk would be economical only when grains are cheap. The high price of whole grains in Western Australia to-day does not favour this method of feeding.

Sprouted grains with 4 or 5 inches of green shoot are a good source of Vitamin A, and oats in particular, are sometimes used by country producers for this purpose.

In order to appreciate why certain foodstuffs are more valuable than others for feeding to poultry and how the different nutrients are taken into the fowl's system, it is necessary to have a knowledge of the construction and functioning of the fowl's digestive system. This system is described hereunder.

THE DIGESTIVE SYSTEM OF THE HEN.

A diagramatic sketch of the digestive system of the fowl is given on page 85.

The digestive system consists of:

1. *The Beak and Mouth.*

The beak is ideally shaped for picking up small objects from the ground and the arrow shaped tongue, with the two points of the arrow directed towards the back of the mouth, aids in directing the food to the gullet, as do the small horny finger-like processes called papilla which are to be found on the rear part of the tongue and on the roof of the mouth.

Glands lining the mouth supply moisture which softens the food, thereby making it easier to swallow. A digestive enzyme called Ptyalin is also secreted from glands lining the mouth. Ptyalin serves to convert starches into maltose. This is the first stage in the breaking down of carbohydrates to the simpler sugars.

2. *Oesophagus.*

The oesophagus, sometimes called the gullet, is the tube which extends from the mouth to the proventriculus or glandular stomach. A distension of the tube just before it reaches the proventriculus is known as the crop.

3. *Crop.*

The crop is situated in front of the base of the neck and lies slightly to the right side. The crop is primarily a food reservoir and the crop of an adult bird will comfortably hold 4-6 ounces of food. The elasticity of the walls of the crop permits of this amount of food being held.

Although the crop has no glands of its own, softening and digestive processes do take place while the food is being stored. The food receives moisture from the oesophagus while on its way to the crop and the splitting of starches into maltose by the ptyalin secreted from the mouth, continues while the food is being held in the crop.

4. *Proventriculus.*

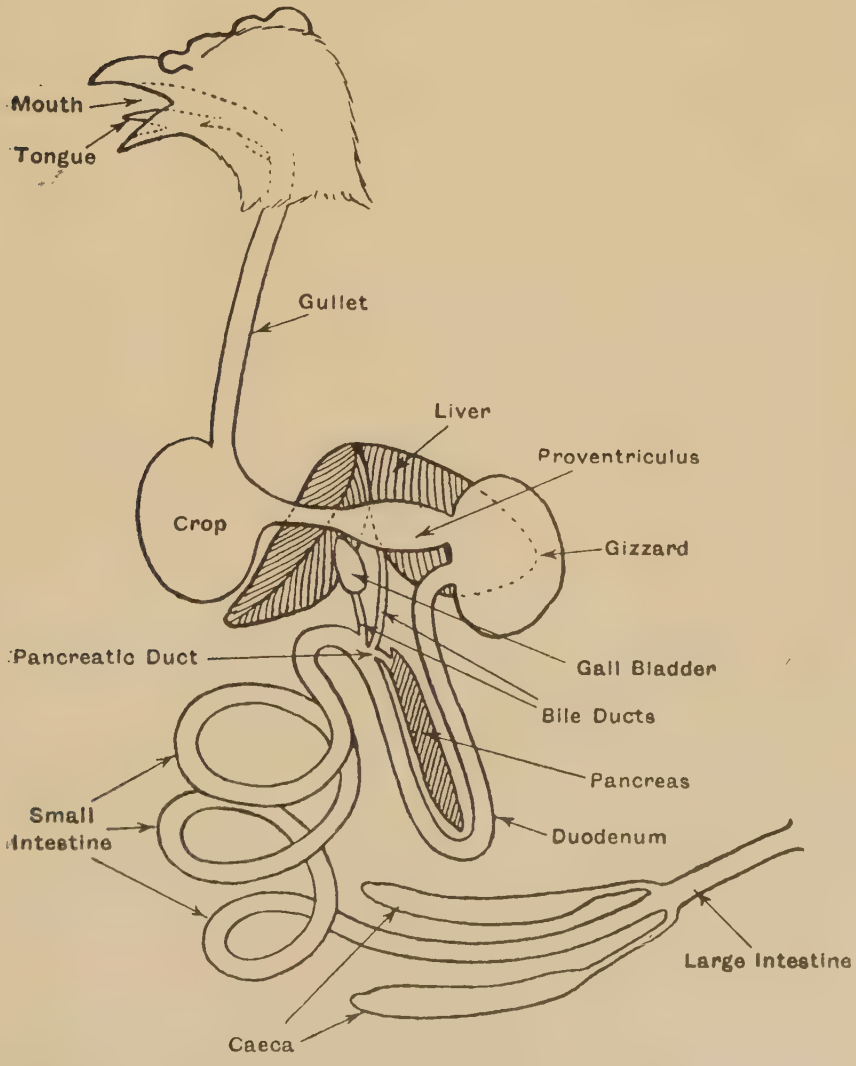
The proventriculus lies between the crop and the gizzard. It is about ¾ inch wide and 1½ inches long in an adult bird and is regarded as the first part of the fowl's stomach, the second part being the gizzard. The inner walls of the proventriculus are abundantly supplied with glands through which the gastric juice is poured. The important digestive enzyme in the gastric juice is pepsin. Pepsin begins the conversion of proteins into simpler nitrogenous compounds which are ultimately broken down into amino acids by enzymes in the digestive juices of the small intestine. This process is described later in the text.

X-Ray photographs show that the food stays in the proventriculus only for a few seconds, before passing to the gizzard.

5. *Gizzard.*

The gizzard is the largest single organ in the fowl's body. It is a muscular, lenticular shaped organ, the inner lining of which is raised into ridges and covered by a horny epithelium. Insoluble grit collects in this organ and assists the strong muscular walls which have continual, slow grinding movements to grind the food to a very fine condition. At the same time the food is being further softened and digested by the moisture and digestive enzymes with which it has been previously provided.

The openings into and out of the gizzard are both situated in the upper side of that organ. On leaving the gizzard, the thoroughly ground and partly digested food enters the small intestine. It is interesting to note that the gizzard is not an essential organ. Fowls have been kept alive for years after the removal of this organ.



Digestive System of Fowl (diagrammatic).

Fig. 17.

By courtesy Scientific Principles of Poultry Feeding Bulletin No. 7 of the Ministry of Agriculture and Fisheries, Great Britain.

6. *Small Intestine and the Glands and Digestive Juices associated with it.*

The upper part of the small intestine forms a "U" shaped loop called the duodenum. Most of the digestion by the gastric juice takes place in the duodenum. Further digestion of the food and absorption of the nutrients takes place in the lower parts of the small intestine. The whole length of the small intestine is lined with intestinal glands which secrete digestive juices.

The food on passing the top of the second arm of the duodenum becomes mixed with bile, a fluid which is manufactured by the gall bladder, and which enters the small intestine at this point through two bile ducts. Pancreatic juice supplied through the pancreatic ducts also enters at this point.

The liver consists of two reddish brown, relatively thin lobes (left and right) which are situated below and behind the heart. The liver is the largest gland in the body.

The gall bladder is attached to the liver and is greenish in colour. The bile which is manufactured in the gall bladder contains alkaline salt, which saponifies, emulsifies and dissolves fats. The steapsin in the pancreatic juice converts the fats to fatty acids and glycerol which are then assimilated by the body.

The pancreas is a creamy coloured organ about 5 inches in length and is suspended in the loop of the duodenum. The pancreatic juice which it secrets contains the digestive enzymes, amylopsin and trypsin. The former converts starch into maltose, and the latter converts protein and intermediate nitrogenous compounds into amino acids. The final breakdown of the maltose into single glucose-like sugars, which are absorbed into the blood stream, is brought about by the enzyme invertase which occurs in the intestinal juices. Another intestinal juice enzyme, is erepsin. The action of erepsin is to convert the intermediate nitrogenous compounds from protein digestion into amino acids.

Assimilation.

The food nutrients are absorbed in solution through epithelial tissue lining the digestive tract by a process similar to osmosis. The glucose-like sugars, the amino acids, and the mineral matter enter directly into the blood stream. The fatty acids and glycerol (end products of fat digestion) enter the lymphatic system which they pass through before entering the blood system.

The intestines, and the blood and lymphatic systems which lie close to the intestine, are all held in position by means of a thin membrane called the mesentary.

Practically all assimilation takes place through the walls of the small intestine; a small amount, however, takes place through the walls of the large intestine and of the caeca.

7. *Caeca.*

The two caeca or "blind guts" are 5-7 inches long and enter the intestines at the point where the small and large intestines join. It is thought that what little fibre digestion does take place, in the fowl, does so in the caeca with the aid of enzymes contained in the food itself.

A large amount of water is also absorbed into the fowl's system through the walls of the caeca.

8. *Large Intestine.*

The large intestine, sometimes called the colon, extends from the small intestine to the cloaca, which is the terminal dilation of the digestive tract. The undigested food and waste products from the kidneys are passed out of the body through the cloaca.

The time taken for the food to pass through the digestive tract of the laying hen is approximately eight hours, and for a broody hen a longer time is required. The time taken depends on the amount of food in the alimentary canal.

NOTES ON FEEDING MATERIALS.

Barley Grain.

This is not a particularly palatable foodstuff and should be introduced into a ration gradually. Approximately one quarter of the grain fed in a mash-grain ration can be barley and this amount can be increased to 50 per cent. should wheat and oats be expensive or difficult to obtain. The palatability of barley can be increased by soaking and sprouting.

Maize.

Maize has a protein content of approximately 10 per cent. and is used extensively in America and to some extent in the Eastern States of Australia. It is not a common grain in Western Australia. Fifty per cent. of the grain in a grain-mash diet can be of maize.

Oats.

The inclusion of oats approximating a 20 per cent. level in poultry rations is recommended by this Department, providing the price is comparable with that of wheat.

Much work has been carried out to determine the relative value of the various grains as poultry feed. It has been found that chicks fed on oat and milk diets grow more rapidly than those which are fed wheat and milk, barley and milk or maize and milk. In one experiment a combination of barley and oats proved to be as effective as oats alone. Gristed whole oats in the diet have been shown to be more effective for growth than hulled oats.

A plump oat typified by the grain of the variety "Guyra" is the type most suitable for feeding to poultry. A plump grain free from long awns is more palatable to adult birds and when gristed proves most satisfactory for feeding in chick mashes. Unless very finely gristed it may be found necessary to remove part of the oat husk which is used in mashes intended for very young chicks. Some husk should be left however, as the husk has a definite value in the ration. The husk has in some cases been reported as a satisfactory control of cannabalism with both adult poultry and with chickens. Oats have a high fibre content and should not form more than 30 per cent. of the total ration.

Rolled Oats.

Rolled oats are not recommended for feeding in quantity to young chickens as they cause digestive troubles and a pasting up of the chickens' vents. Particularly is this likely to occur in chicks a few days old that are given rolled oats to eat and nothing else.

Rolled oats, could, however, be included with advantage, in rations for older stock.

Soyabean Meal.

Soyabean meal is an excellent foodstuff for poultry, but unfortunately there is little available for feeding to poultry in this State. It is prepared from soyabeans by removing the oil and grinding the resulting press cake. For best results the soyabean must be thoroughly cooked or roasted. This is indicated by a pleasant nut like taste and a light brownish or tan colour.

Should supplies of this foodstuff become available at reasonable prices quite large quantities could be used by the poultry industry in this State.

Up to 20 per cent. of soyabean meal has been fed in poultry rations to advantage. The inclusion of meatmeal, fishmeal or milk to rations containing soyabean considerably improves the nutritive value of these rations. This is because of the excellent supplementary effect of the protein of these foodstuffs to soyabean protein.

Linseed Meal.

Linseed meal is a rich source of vegetable protein (23 per cent,) and is the ground residue after extraction of part of the oil from ground flax-seed. It is very doubtful, however, if linseed meal has any beneficial effect when included in the diet and there is evidence to suggest that when fed in excess of four per cent. of the ration, linseed meal will depress the growth rate of chicks and cause a laxity of the bowels in all classes of poultry. H. I. MacGregor and J. McGinnis (Poultry Science—March 1948, Vol. XXVII, No. 2) showed linseed meal to contain a toxic substance which depressed chick growth. They also showed the toxic factor to be water soluble as the growth depression was not noticeable when chicks were fed water- treated material. They obtained marked growth depression when non-water-treated linseed-meal was fed.

Charcoal.

The use of charcoal in poultry rations is not recommended as it is likely to do more harm than good, particularly if the ration being fed contains the minimum amounts required for normal health, of the essential Vitamins A.G.K. and the anti-gizzard erosion factor. H. J. Almquist and D. Zander demonstrated this and their findings are recorded in the article on "adsorbing charcoals in chick diets" proc. Soc. exp. Biol. and Med. Journal 45-303, 1940.

On the other hand much investigational work has been carried out in order to demonstrate the beneficial effects of feeding charcoal, but without success.

Molasses.

Molasses is practically pure sugar, and although a good source of pantothenic acid, it is very doubtful if the feeding of molasses to poultry is warranted. When fed in excess of five per cent. of the total diet molasses is inclined to induce laxity of the bowels and this will cause considerable egg soilage.

Blood Meal.

Blood meal contains 80 per cent. of protein, but should not be used in the mash at higher than a five per cent level because of its unpalatability.

Common Salt. (Sodium Chloride.)

Salt provides the two elements Sodium and Chlorine. It is of vital importance in the blood plasma, in the physiology of the cells of the body, and for the formation of hydrochloric acid in the stomach.

Under certain conditions the inclusion of common salt in rations at low levels has resulted in better growth and more efficient food utilization in chickens, and better body weight and better egg production in laying hens. Cannibalism and feather picking in chickens have, in some instances, been traced back to a salt deficiency.

The fowl's requirements for salt are very small and rations containing adequate levels of meatmeal should not require the addition of common salt for optimum results as most meatmeals contain sufficient salt to meet the bird's requirements, when fed at proper levels. Should the ration be deficient in meatmeal, common salt could be added at the rate of ½ per cent. to adult rations and ¼ per cent. to chick rations.

The feeding of salt at two to three per cent. of the ration is not warranted and may be injurious. The salt should always be in a fine condition as salt poisoning may follow the eating of lumps of salt. Salt is most easily fed in the mash. The fine salt, preferably sieved, is mixed with a small amount of one of the ingredients, usually the meatmeal, and this mixture is then evenly spread and distributed throughout the mash by thorough mixing.

Farmers who have to rely on ground water for feeding to their poultry and which they suspect to contain excessive salt, should forward a sample to the Government Chemical Laboratories for analysis. A fee of 5s. should accompany each sample. Two hundred grains of salt per gallon of drinking water is a safe limit for poultry and is equivalent to 22 ozs. of salt per 100 lb. of the total ration.

WHEAT AND ITS PLACE IN THE POULTRY RATION.

Wheat is fed in large quantities to poultry in Western Australia, but it should be realized that there is a limit to wheat feeding. When fowls are fed on wheat alone or when wheat constitutes too large a portion of the total diet, production will be adversely affected. Their growth rates will be slow and their egg production low. This is because wheat in itself is an unbalanced food. It is rich in carbohydrates, contains only small amounts of certain essential vitamins and minerals and most important of all, is low protein.

The protein requirements of laying hens have already been discussed and it has been recommended that laying fowls receive a ration which contains from 15 to 15.5 per cent. of protein. Wheat varies considerably in its protein content and this variation is dependent on the variety and on the conditions under which it is grown. Higher protein containing wheats (up to 18 per cent. of protein) are obtained from the low rainfall areas of the State but samples grown in the wetter districts have been shown to contain only eight per cent. On an average Western Australian wheats contain approximately 10 per cent. of protein which is considerably lower than 15¼ per cent.—the amount recommended for laying hens. Because of the high carbohydrate, low protein content of wheat, fowls produce fat and not eggs when fed on wheat alone. If fowls are to be kept on economical lines it is necessary to supplement the feeding of wheat with adequate amounts of protein-rich foods of animal origin to ensure that the hens receive sufficient protein in their diet.

In practice wheat is fed in many different ways. The principal methods are as follow:—

1. *As grain in the evening.*—If too much wheat is fed is the evening, the consumption of the higher protein-containing mash is automatically restricted and the ration may become unbalanced. Fowls on a 15.0 per cent. protein,

mash-whole wheat diet (2½ ozs. mash-1½ ozs. wheat per bird per day) will have the protein content of the ration reduced to approximately 14.0 per cent. when wheat containing 10 per cent. of crude protein is fed at the rate of 2 ozs. per bird per day instead of the predetermined necessary level of 1½ ozs. per bird per day.

2. *In the gristed form* as part of a mash (wet or dry) (refer mill offal versus gristed grains pages 94 and 95).

3. *As a whole grain diet entirely.*—It has already been shown that wheat by itself is an unsatisfactory foodstuff for poultry. Feeding tests with laying hens have shown that when wheat forms the major portion of the diet (80 per cent. or more) and meatmeal provides the only animal protein, a greater total protein intake is required for satisfactory production, than under a system of feeding where mill offal and other foodstuffs are used to make up the ration. However skim-milk is an excellent protein supplement and milk and meatmeal together form an excellent supplement to cereal rations.

Suggested Rations using Meatmeal and Skim or Whole Milk to Supplement Wheat are as follow.

Ration 1.—One hundred laying hens will eat approximately 25 lb. of dry food per day, which means that this number of hens when on a 15.2 per cent. protein ration will eat ¼ of 15.2 = 3.8 lb. of protein per day. When milk is fed ad libitum 100 hens will drink five gallons = 50 lb. per day and this will contain 1.85 lb. of protein. When milk is fed at this level, 100 hens will eat in the vicinity of 20 lb. of wheat, if the wheat is fed ad lib. Normally 25 lb. of dry food are eaten by 100 hens daily, but the feeding of milk results in less dry food (in this case grain) being eaten. Twenty pounds of wheat will provide 2.0 lb. of protein giving a daily protein intake of 1.85 + 2.0 = 3.85 lb. per 100 hens per day.

In order to ensure satisfactory egg-shell strength adequate levels of calcium and phosphorus are required. This necessitates 7 lb. of bonemeal and 3 lb. of oyster flour being consumed together with each 100 lb. of wheat. As 100 lb. of wheat will last 100 hens approximately five days on this system of feeding the above amounts of mineral supplements will last 100 birds five days. In order to get the birds to eat the bonemeal and oyster flour these supplements could be added to a small quantity of the grain that had previously been soaked in skim-milk, but better still by gristing the wheat (coarsely) and feeding it as a dry mash the mineral supplements could be easily incorporated.

The protein, calcium and phosphorus content of the ration is determined as follow. In order to follow the method of working, the reader is referred to that section dealing with the feeding of the trial birds at Muresk on pages 75 to 78. The quantities of materials listed in this Table would be sufficient for one hundred hens for five days.

Ingredient.		Protein.	Calcium.	Phosphorus.
	lb.	lb.	lb.	lb.
Wheat	100	10·0	·04	·22
Milk, 250 lb.	24 (solids)	8·8	·35	·30
Bonemeal	7	1·4	1·40	·84
Oyster Flour	3	....	1·14	....
Total	134	20·2	2·93	1·36
	100	15·0	2·2	1·0

Ration 2.—When liquid milk is in short supply the following ration, fed ad lib. as a dry mash together with three gallons of liquid milk to each 100 hens daily, should give good results:—

Ingredient.	lb.
Wheatmeal	100
Meatmeal	7½
Bonemeal	5
Oyster Flour	3

Ration 3.—When milk and mill offal are not available the following ration should give good production:—

Ingredient.	lb.
Wheatmeal	80
Meatmeal	15
Bonemeal	2
Oyster Flour....	2

MILK.

Skim or separated milk is the form of milk most readily available to the farmer. Skim-milk is as valuable as whole milk for feeding to poultry as butter-fat has little nutritional value.

From a growth-promoting and egg-producing point of view, milk in its various forms is considered to be the most effective protein food known, as it contains all the amino acids known to be essential to poultry. It is also recognised as a valuable source of minerals and water-soluble vitamins (particularly riboflavin). Apart from its highly regarded nutritive value milk is considered to possess special therapeutic properties. Lactose (milk sugar) is converted to lactic acid in the process of souring in the small intestine. Lactose favours the development of acid-producing bacteria in the intestines and these "friendly germs" tend to decrease the objectionable putrefactive bacteria.

The forms in which milk are usually fed include liquid skim-milk, liquid whole milk or liquid whey, and dry or powdered skim-milk, butter-milk or whey.

Milk is particularly valuable for feeding to chickens up to eight weeks of age and to breeding stock. Fattening gruels are greatly improved if made with milk. A gruel consisting of 40 lb. of liquid milk and 30 lb. of dry material is suitable for fattening cockerels. (See page 110.)

Feeding Skim or Whole Milk.

When skim-milk is available in quantity there should be no difficulty in getting 100 adult hens to drink five gallons per day. At this latter level the crude protein level of the ration (dry food plus milk) is increased by 1.85 lb. (Milk contains approximately 3.7 per cent. protein and five gallons of milk weighs 50 lb.—therefore $50 \times \frac{3.7}{100} = 1.85$ lb.). When skim-milk is available at this level, meatmeal is not required in the ration.

In hot weather it is difficult to prevent the milk from souring. This is of little consequence as sweet and sour milk are utilized by the birds equally well. Once sour milk feeding is commenced, however, it should always be fed in this form for best results. The same applies to feeding milk in a sweet form as the birds do not appreciate changes of this nature in feeding.

Milk vessels should be thoroughly scrubbed out with cold water followed by hot water each day as fowls which drink milk from filthy troughs will quickly develop severe enteritis. During the summer months flies congregate round milk vessels in large numbers. Flies are one of the intermediate hosts of tapeworms.

Dried Whey.

Whey powder contains only 12.5 per cent. of protein and is primarily a carbohydrate-rich foodstuff containing 65 per cent. of lactose. Whey powder should not constitute more than five per cent. of the ration as the lactose is converted to lactic acid and excessive amounts of lactic have been known to produce blistering of chickens' bodies, a condition referred to as "Anasarca."

Buttermilk powder is approximately three times more valuable as a protein rich foodstuff than whey powder and feeding materials such as bran and pollard contain more protein than whey powder. Whey powder cannot therefore be regarded as a rich foodstuff from a protein aspect, and certainly cannot be regarded as a substitute for butter-milk powder. Whey powder does, however, contain almost as much riboflavin as butter-milk powder, and is, therefore, a useful source of riboflavin.

TOXIC MATERIALS.

Cases of poisoning of poultry are reported to this Department from time to time. The losses are sometimes heavy and the cause of death can usually be traced to the ingestion of one of the following materials.

(a) *Decomposed meat and bones causing* Botulism. Birds thus affected lose use of their legs and neck muscles and lie with heads stretched out on the ground. Death is fairly sudden.

(b) *Cauliflower leaves or cabbage leaves* or other vegetables which have been sprayed or dusted with arsenical or D.D.T. containing insecticides. Poisoning from this source is most likely to occur where the farmer obtains greenfeed from a market gardener. It is always important to know any spray treatment the cauliflower leaves etc. have received and to thoroughly wash greenfeeds should they be suspected of containing poisonous material.

(c) *Pickled grain.* Losses through this cause are most likely to be experienced by farmers in the wheatbelt who have a carry over of seed wheat. Grain which has been pickled with copper carbonate can be fed to poultry providing the grain is first thoroughly washed with water.

(d) *Poisonous weeds, berries and seeds.* Weeds which are sometimes fed and which have been shown to have a detrimental effect on poultry include doublegees (*Emex australis*) marshmallows (*Malva parviflora*) etc. These weeds depress egg production and may have a deleterious effect on their quality, e.g. marshmallows cause pink whites in eggs while the excessive feeding of rape, field penny-cress, shepherd's purse and certain natural grasses which abound in orchards in particular, will give an olive colouration to egg-yolks.

(e) Insects.

In one instance at Ravensthorpe (W.A.) 60 fowls died within 15 minutes of ingesting large quantities of ants (variety monomorium bicorne).

(f) Mouldy mash or grain.

(g) Excessive amounts of salt.

(h) Excessive dosage with Black Leaf 40 (Nicotine Sulphate), aconite, carbon tetrachloride and other drugs.

GRITS FOR POULTRY.

It is important to realize that two types of grit are essential for poultry. These are classified as—

1. Insoluble grit.
2. Soluble grit.

Insoluble Grit.

Poultry must have access to insoluble grit if they are to efficiently utilize their food. Insoluble grits include flint, granite dust, blue metal dust or coarse sand. These materials are insoluble in hydrochloric acid, a component of gastric juice. The insoluble grit accumulates in the gizzard and remains there for some time so that if intensively housed poultry have access to insoluble grit every two months, this is usually sufficient. The main function of insoluble grit is to assist the gizzard macerate fibrous foods and to assist in rupturing the walls of plant cells. The rupturing of the cell walls enables the digestive juices to act on the more soluble nutrients within the walls. In this way more efficient use is made of the plant food.

The importance of insoluble grit as an aid to the efficient utilization of grain food was demonstrated by Mangold and Kato ("The Scientific principles of Poultry Feeding"). They found that 57 grams of wheat a day were required to maintain the weight of a bird whose gizzard was grit free and that only 35 grams were required when the gizzard contained grit.

The inefficiency of limestone grit (soluble grit) as a substitute for insoluble grit was demonstrated by Ferber & Brüggemann (Scientific principles of Poultry Feeding) who fed three groups of one month old white leghorn chickens as follows:—

Group 1—Fattening diet only.
Group 2—Fattening diet plus limestone grit
Group 3—Fattening diet plus flint grit.

The experimental period was for seven weeks and for every lb. live weight increase the birds in—

Group 1 consumed 6.4 lb. mash and 2.8 lb. grain. Those in
Group 2 consumed 7.5 lb. mash and 3.6 lb. grain. Those in
Group 3 consumed 5.4 lb. mash and 2.5 lb. grain.

Soluble Grit.

Soluble grits include calcium carbonate-rich materials such as limestone, cockle shell and oyster shell grits that are soluble in hydrochloric acid and which do not aid in food maceration. The function of soluble grits is to supply calcium which is required by birds for proper bone development and egg shell formation. The calcium requirements for the various classes of stock (growing chicks, laying hens, etc.) are fairly well known and are given on page 51.

The importance of controlling the calcium intake of the birds and the advantages of supplying a certain level of a calcium-rich foodstuff such as oyster flour, in the mash instead of giving the calcium-rich foodstuff, e.g. shell grit, to the birds ad lib. is explained on page 51.

PREPARED MASHES.

Many different prepared mashes for poultry are available in Western Australia, but their nutritional values are so variable that it is not possible to make definite recommendations as to the way in which they should be fed.

The farmer who purchases prepared mashes should be conversant with their protein and mineral content. Mashes which contain less than 15 per cent. of protein should not be fed in conjunction with grain to laying hens unless the appropriate amount of meatmeal is added to the mash to bring the protein content of the total ration up to a minimum of 15 per cent. A laying mash when fed with grain should contain 18-20 per cent. of protein. The same principles should be applied to chick mashes.

All stock foods are registered at the Department of Agriculture under the Feeding Stuffs Act 1928-46 and the registration for the year commencing July 1st, 1949, is published in the September, 1949, issue of the Journal of Agriculture. New registrations are required each year and these are published in the Journal from time to time.

MILL OFFAL VERSUS GRISTED GRAINS IN A MASH.

Mill offal and gristed grains usually provide from 80-85 per cent. of the weight of a mash, and three main factors determine the relative amounts of each of these foodstuffs it is advisable to use.

These factors are their relative

1. Cost.
2. Protein content.
3. Fineness (which influences palatability).

1. *Cost.*

The present day (March, 1950) retail price of bran and pollard is 2s. 5d. per bushel (20 lb.), of gristed oats 6s. 9d. per bushel (40 lb.), and of gristed wheat 8s. 7d. per bushel (60 lb.). On this basis:

100 lb. of bran and pollard costs 12s. 1d.
100 lb. of gristed oats costs 16s. 10½d.
100 lb. of gristed wheat costs 14s. 4d.

From these figures it will be seen that the greater the proportion of mill offal a mash contains, the cheaper the mash will be.

These foodstuffs are of course continually changing in price and when grains are available at a lower price then the possibility of increasing the gristed grain content of the mash can receive greater consideration.

2. *Protein Content.*

Average crude protein values for Western Australian foodstuffs are:

Bran 14.0 per cent.
Pollard 13.5 per cent.
Wheat 10.0 per cent.
Oats 9.0 per cent.

It is therefore, obvious that the higher the proportion of bran and pollard which a mash contains in relation to its gristed grain content the smaller the amount of protein rich, highly priced foodstuffs like meatmeal and buttermilk powder that have to be included in a mash in order to raise its protein content to a satisfactory level.

This point is illustrated by taking two mashes of equal protein content, one composed chiefly of gristed grains, the other of mill offal and examining their relative cost (based on present day retail prices ex store).

Mash 1.				Mash 2.			
Ingredient.	lb.	Crude Protein.	Cost.	Ingredient.	lb.	Crude Protein.	Cost.
			s. d.				s. d.
Gristed Oats	30	2·7	5 1	Bran	50	7·0	6 0½
Gristed Wheat....	50	5·0	7 2	Pollard	40	5·4	4 10
Meatmeal	15	7·5	3 9	Meatmeal	6	5·0	1 6
	95	15·2	16 0		96	15·4	12 4½
	100	16·0	16 9½		100	16·0	12 10½

(Note. These are only theoretical rations to illustrate the point in question).

The difference in price for 100 lb. of these two theoretical rations is 3s. 11d. The difference in cost of feeding 1,500 birds for a year on two rations which vary in price by only 2s. for 100 lb. is approximately £137 which is equivalent to £2 13s. 0d. per week. This demonstrates the importance of the farmer investigating the economics of various feeding systems which use different foodstuffs before deciding on any particular feeding programme.

3. *Fineness.*

The mechanical condition of a mash is important. Mashes which contain too much fine material such as pollard and finely gristed grains are unpalatable. On the other hand mashes which are bulky and which contain too much coarse, fibrous material are not suitable because the birds are unable to consume enough of these mashes to provide them with sufficient nutrients to perform their various functions (egg production etc.) at an optimum rate.

Most farmers are forced these days to include a percentage of gristed grains in their mashes and the mechanical condition of the mash can be considerably altered depending on the degree of fineness to which the grains are gristed. The wheatmeal in a mash which contains a lot of bran can be more finely gristed than when used in a mash which contains only a small amount of bran.

A relatively open, palatable mash is most desirable. Because of this the inclusion of a large proportion of pollard in poultry mashes is not recommended. A very fine mash, fed to chickens in particular, will result in packing of the food in the nasal cleft and mouth. A balling of the food in the digestive tract may also occur and this will result in incomplete digestion of the food nutrients with consequent digestive troubles.

GREENFEED.

A regular supply of young succulent greenfeed during the summer months is only possible where some system of irrigation is available. The "sprinkler system," using standards and butterfly sprinklers is the most popular system in

this State. With this type of watering and where the water pressure is reasonably good, the rows of sprinklers should be approximately six yards apart and each standard should be six yards distant from the nearest standard in the same row. Staggering of the standards so that each standard is equidistant from the two nearest standards in the next row will give better coverage.

Summer greenfeed crops which are commonly grown for poultry in this State are lucerne, elephant grass, and maize. The two former are perennials and approximately three-eighths of an acre of these crops is required to provide 1,000 laying birds with enough greenfeed during the summer months. It is recommended that a 1,000 bird farm have three-eighths of an acre of lucerne, and one-eighth of an acre of irrigated land in addition which could be used for growing such a crop as barley for autumn—early winter greenfeed, and maize or silver beet, if required for late spring—early summer greenfeed. The plantings of maize should be made in rotation so that the bulk of the crop is cut when it is three to four feet in height. Maize grown under good conditions will take approximately six weeks from the time of seeding to reach three feet in height and a further 10 days to grow to four feet. The disadvantages of this crop is the rapidity with which it becomes coarse. Of the three greenfeed crops mentioned lucerne has several advantages. Being a legume it has a high protein content and hence a high nutritive value. It is easily grown and cultivated. It is relished by the birds, responds to repeated cuttings and is easily handled. Because of these attributes it is known as "The King of Fodder Crops." One stand will continue to give satisfactory yields for fifteen years or more.

The main features which make lucerne a superior greenfeed are its high protein, mineral and vitamin content.

Protein Content.

Lucerne contains at least twice as much protein as a mixture of other generally recognised poultry greenfeeds (except clovers), and green lucerne cut at the right stage contains approximately four times as much digestible protein as green maize.

The time at which lucerne is cut, the type of soil on which it is grown and the manurial treatment will influence its protein content. As with other green fodders, the older the lucerne the lower its protein content. To obtain a bulk of lucerne with a high protein content the lucerne should be cut when in bud.

The following table gives the per cent. protein of lucerne in its various growing stages and shows how quickly the protein content falls off once flowering is over:—

	Crude Protein per cent.
At about 10 inches high	5.4
Just before flowering	4.3
Just after blooming	2.9

Lucerne protein is of good quality, i.e., it has a high biological value. It is not a "complete" protein, but closely approaches animal protein in quality and as a vegetable protein is surpassed in quality by only that of the soya bean and yeast.

Fig. 18A. *Government Photographer.*

Fig. 18B. *Government Photographer.*

Although generally regarded as a summer crop Lucerne can be grown during winter in the Perth metropolitan area, as these two photographs taken on Mr. J. Duncan's property, Belmont, show. The photographs were taken in August, 1949.

APPROXIMATE PROTEIN CONTENT OF LUCERNE IN ITS VARIOUS FORMS.

	Green Lucerne.	Lucerne Hay.	Dehydrated Lucerne Meal.	Dried Lucerne Meal.	Good Grade Lucerne Dust.
Per cent. crude protein	4½	14½	17½	15	22

Mineral Content.

Lucerne contains a complete range of those minerals known to be required by the fowl, and is higher in minerals than other greenfeeds. The mineral content of lucerne is approximately 2.4 per cent., compared with 1.6 per cent. for a mixture of greenfeeds comprising young cereals, dandelion, cabbage and clovers.

Vitamin Content.

Lucerne is richer in vitamins than any other greenfeed commonly cultivated for poultry.

Lucerne Chaff.

Lucerne chaff is sometimes fed to poultry when fresh greenfeeds are not available. The quality of different samples of lucerne chaff varies considerably. Good quality lucerne chaff has a high leaf content in proportion to stem and it has a rich green colour. It contains the original vitamins and yolk colouring pigment in amounts only slightly lower than the fresh material, except for carotene (Vitamin A precursor), which decreases rapidly during curing.

The carotene content of greenfeed begins to diminish as soon as the greenfeed is cut. The carotene content is considerably reduced when the greenfeed dries slowly at warm temperatures and is exposed to light as is the case with sun curing. Best quality Vitamin A-rich lucerne chaff is obtained when dried quickly in the absence of light, under artificial conditions.

Cryptoxanthin is another precursor of Vitamin A. It is found in yellow maize, and like carotene, it is unstable and loses its provitamin A content progressively with age.

Three different methods for curing lucerne hay result in different levels of carotene being retained by the plant. These conditions are:

1. Artificially-dried (dehydrated) lucerne chaff is usually higher in carotene than

2. Sun cured lucerne which in turn has a higher carotene content than

3. Plant material which is dried slowly as in dull weather at warm temperatures and which is exposed to light.

Irrespective of the initial carotene content of the lucerne chaff, the carotene content is quickly destroyed on storage. However, storage does not lower the protein, riboflavin, pantothenic acid, members of the Vitamin B complex and Vitamin K (anti-haemorrhagic vitamin) content of lucerne chaff.

Average carotene values of various feeds are:—

Feeds.	Microgrammes of Carotene per Gramme of Feed.
Carrots	900
Young leafy grass and cereals	350
Grass and lucerne silage	300
Dehydrated lucerne meal	70–240 (Average 150)
Sun dried lucerne meal	20–120 (Average 50)
Yellow maize	80
White maize, wheat, oats, barley, bran, pollard	Practically Nil

The importance of cutting lucerne for lucerne chaff and meal at the right time is illustrated by the following figures which show how the fibre content of the sample increases and the protein content diminishes as the plant matures.

	Protein Per cent.	Fibre Per cent.
Choice leafy lucerne chaff	18–22	25–28
Good quality lucerne chaff	16–20	27–30
Poor quality lucerne chaff (plants too old)	10–12	31–35

Where lucerne chaff is fed in place of greenfeed, 10 per cent. is usually used in the mash for an all mash diet and 15 per cent. for a mash-grain diet. In all nutrients except carotene, this is equivalent to about one ounce of greenfeed per adult bird per day.*

Lucerne chaff is best fed in a wet mash. When used in this way the chaff should be soaked over-night in water, in sufficient quantity to mix the wet mash the following morning.

Although generally regarded as a summer crop, lucerne, when given attention during the winter months will continue to produce throughout the year. The photographs (Figs. 18A and 18B), taken on Mr. J. Duncan's property at Belmont support this claim.

The growing of lucerne in Western Australia is described in the Departmental leaflet No. 634 by H. G. Elliot, Agrostologist.

In certain localities near Perth there appears to be a deficiency of copper in the soil and many poultry farmers obtain much improved growth from their lucerne stands by top dressing with small quantities of copper sulphate (blue stone). One application of copper sulphate at the rate of 5 lb. to the acre would probably be sufficient for two or three years. If copper sulphate is used too liberally more harm than good will result, as only a trace of copper is required. To ensure good growth of lucerne the seed should be treated with bacterial culture before it is planted.

Frequency of Cutting.

The more frequent the cuttings the more succulent and nutritious the greenfeed, but the bulk factor also enters into the economics of cutting greenfeed. Taking these two factors into consideration, lucerne should be cut when in bud and elephant grass when about two feet six inches tall, i.e., before the cane develops.

Elephant grass is grown extensively on the coastal plain but cannot be recommended for localities that have severe frosts. It will survive mild frosts, however, providing it is covered at the time with a dense growth of natural grasses and weeds.

* When fed at these levels, and when fresh greenfeed is entirely absent from the diet it would be advisable to feed a recognised Vitamin A-rich oil at the strength recommended by the manufacturer. This would ensure an adequate Vitamin A intake by the birds.

Winter Greenfeeds.

Of the cereals, barley is perhaps the best greenfeed to grow. Early plantings of this cereal can be made in April. If cut when young (about one foot high), several cuttings can be made from one stand.

Cauliflower and cabbage leaves are sometimes fed. Arsenical sprays are often used in the spraying of these plants to protect them against insect attack so that the history of the leaves should always be known before they are fed to poultry. Many cases of arsenical poisoning of poultry by feeding leaves which have been sprayed with arsenic have been reported.

Government Photographer.

Fig. 19.

A nice stand of lucerne on Mr. J. Duncan's property at Belmont. The lucerne is in flower and the rapidity with which lucerne develops stalk and becomes fibrous, particularly during the summer months, is illustrated by the plant in the centre foreground. The photograph was taken in December, and the bulk of the plot was cut a few days before this photograph was taken, when the lucerne had a higher nutritional value.

Amount of Greenfeed Consumed by Poultry.

One hundred laying hens will consume up to 14 lb. of finely cut greens per day when fed ad lib., and when quantities approaching this amount are eaten, a saving of up to 10 per cent. of other ingredients in the diet (mash and grain) may be effected. Greenfeed is a bulky foodstuff, however, and it is doubtful if the feeding of excessive amounts is in the best interests of the birds. Six pounds of good quality greenfeed per 100 birds per day (one ounce per bird per day) is sufficient to provide the Vitamin A requirements of laying hens. Everything taken into consideration it would appear that

10 lb. per 100 adult hens per day is the most satisfactory level at which to feed greenstuff. On this basis, and when finely cut greenfeed comprises ⅔ths of the bulk of the morning wet mash, approximately 6 lb. (¾ kerosene tin full) remain to be fed to each 100 birds as an evening feed. One reasonably packed kerosene tin full of finely cut greenfeed weighs 8 lb.

Open Range.

When fowls run on good young pasture as is the case for many months of the year in certain areas in the South-West of this State, there is no necessity to provide extra greenfeed. Also the double yard system of poultry housing which is advocated by this Department (see "Requirements in designing the layout of and buildings for a poultry farm," by E. Lovegrove, and S. Frome), enables rotational cropping of the runs to be practised during eight months of the year and this practice achieves some saving in the cutting and chaffing of greenfeed. Good range which enables the birds to pick up seeds, grubs etc., in addition to providing ample greenfeed can result in a saving of up to 10 per cent. of mash and grain.

Olive Yolks and Pink Whites.

Certain greenfeeds have a detrimental effect on egg quality. The two most striking conditions are "Olive Yolks" and "Pink Whites." When rape, field pennycress or shepherd's purse are fed in excess, the yolks may take on an olive colouration. When marshmellow is fed in excess the whites have been known to turn pink. The "pink white" condition in eggs has also been brought about by the feeding of more than five per cent. of cotton seed meal in the ration.

Importance of Greenfeed Quality.

The feeding of too fibrous, unnutritious greenfeed to poultry is much in evidence in this State at certain times of the year, and the resulting unthriftiness and losses amongst the birds causes the industry considerable economic loss. During the autumn and spring, particularly the latter, the farmer sometimes finds himself short of young leafy greens and has to feed his birds coarse fibrous greenstuffs, which are practically valueless from a nutritional point of view. The high incidence of Avitaminosis A (Vitamin A deficiency) which occurs amongst growing chickens in particular, during late spring and early summer in this State, could be greatly reduced if farmers would make early plantings of recognised summer greenfeed crops to carry them over this difficult period, and rely less on the natural grasses which by this time have lost their dietary usefulness.

Two crops which grow rapidly and which are suitable for spring planting are silver beet, and maize. If properly tended a well-established lucerne plot will also give early summer greenfeed.

Mineral Content of Greenfeed.

Compared with other vegetable foods young leafy greenfeed has a relatively high mineral content, but even so it contributes only a small amount of the bird's total mineral requirement. Lucerne, one of the richest calcium-containing greenfeeds, supplies only 1/30th of a bird's requirements for this mineral, when eaten at the rate of 1.6 ounces per day.

TABLE 9.

WEIGHTS OF FEEDING MATERIALS.

Ingredient.	Volume.	Weight.
	Kerosenetinful.	lb.
Bran	1	12
Pollard	1	20
Wheatmeal	1	28
Gristed Oats	1	20
Wheat (whole grain)	1	32
Oats (whole grain)	1	22
Barley (whole grain)	1	23½
Meatmeal	1	22
Oyster Flour	1	44
Bonemeal	1	40
Buttermilk Powder	1	12
Salt	1	50
Greenfeed (finely chaffed)	1	8

FEEDING CHICKENS.

The most common method of feeding young chickens in Western Australia and the one advocated by this Department, is the very convenient "all mash" system. Under this system a dry "starter mash" of known nutritional value should be placed in hoppers which have eating space sufficient to permit all the chickens to feed at the same time if necessary. For the first few days the mash is usually placed in shallow trays about one inch in depth.

TABLE 10.

16 PER CENT. PROTEIN MASHES FOR CHICKS 1–6 WEEKS OF AGE.

Ingredient.	RATIONS. To be fed under an all mash system.						
	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Bran	30	36	36	40	20	....	15
Wheatmeal	32	30	22	28	20	80	40
Pollard	10	20	10	....	20	....	15
Gristed Oats	20	....	10	20	20	....	20
Meatmeal	10	8	8	8	8	14	10
Dried Buttermilk*	4	4	4	4	4	4	4
Bonemeal	1½	1	1	1	1	....	1¼
Total	107½	99	91	101	93	98	105¼

* NOTE.—In the above mashes dried buttermilk is used as a source of riboflavin. Where whey powder is used as a source of this vitamin instead of dried buttermilk, use 4½ lb. of whey powder instead of 4 lb. buttermilk powder, and add 2 lb. of meatmeal to maintain the protein content of the mash. Buttermilk powder and whey powder have almost the same riboflavin content, but buttermilk powder has three times the amount of protein that is contained in whey powder. The quantities of meatmeal given are for a 50 per cent. protein meatmeal per cent. Should the meatmeal contain only 35 per cent. of protein, 1 3/7th lb. of meatmeal would be required for every lb. of 50 per cent. protein meatmeal, in order to provide the same amount of protein.

The depth of the tray can then be increased to two inches as by the end of the first week the chicks will begin to scratch more vigorously. The trays can then be replaced by a hopper, the trough of which is provided with a lip to prevent waste. Chicks can be given a starter mash right from day old. The starter mash is so named because of its suitability as a ration for young chickens that are growing fast. The salient feature of this mash is its high protein content, which should be at least 16 per cent. When chickens reach the age of approximately six weeks there is a falling off in the growth rate and a lower protein-containing mash or "growing mash" should be substituted for the "starter mash," or, alternatively, grain feeding can be introduced.

The former course is recommended to farmers who wish to continue with all mash feeding, and the latter course to those who intend feeding mash and whole grain to their laying pullets.

Should it be decided to follow the former course the protein content of the mash can be lowered from 16 per cent. at six weeks to 14 per cent. at 13 weeks by simply reducing the quantity of meatmeal fed as the chickens become older. It is suggested that this be accomplished in the manner outlined in Table 11.

Table 11.

Age of Chicken.	Per cent. Protein Content of mash.	Rate of reducing meatmeal in each 100 lb. of mash when meatmeal contains 50% protein.
		lb.
1-6 weeks	16	....
7 weeks	15·5	1
9 weeks	15·25	½
10 weeks	15·0	½
11 weeks	14·75	½
12 weeks	14·5	½
13 weeks	14·0	1

In the above table it has been assumed that the meatmeal contains 50 per cent. of crude protein. To bring about a reduction of the protein content by two per cent. spread over six weeks would necessitate the 13 week old chick mash having four lb. less meatmeal per 100 lb. of mash than that contained in the mash given the six-week-old chicks. Had the meatmeal contained 35 per cent. of protein a reduction of 5 5/7th lb. would have had the same result.

It is very desirable to include about four percent of dried buttermilk in the mash until the chicks are ten weeks of age. This level of buttermilk powder will ensure that the mash contains sufficient riboflavin, and valuable amino acids required for optimum growth will also be provided.

If dried buttermilk is difficult to procure, the quantity of buttermilk powder fed can be reduced from four per cent. to one per cent when the chicks are 10 weeks of age. This will result in a lowering of the protein content of the mash by approximately one per cent, so that in a 16 per cent. protein mash which contained both meatmeal and four per cent. of buttermilk powder, instead of removing four lb. of meatmeal from the mash during the 7-13 week old stage in order

to reduce the protein content to 14 per cent., another and more economical way which would obtain the same result would be to reduce the meatmeal by two lb., and the dried buttermilk powder by three lb. The remaining one lb. of buttermilk powder which the chicks 13-22 weeks old received would ensure that their ration contained sufficient riboflavin and the small amount of amino acids provided would help supplement the other amino acids in the diet. The protein content of the diet fed to chicks 13-22 weeks of age should remain constant at 14 per cent.

It is sound practice to de-worm growing stock when they are 10 weeks of age (a fortnight before they are vaccinated against chicken or fowl-pox) and again when about 18 weeks of age just before the pullets come into the lay. If Blackleaf 40 is used as a vermifuge, birds on an all-dry mash system of feeding can be given a non-medicated wet-mash for two or three days, followed immediately by the treated mash for six consecutive days, each evening. After a period of 8 or 9 days of wet-mash feeding, all-dry mash feeding can be restored. During the 8 or 9 days the consumption of dry mash should be restricted to about half the usual amount, by closing the hoppers for part of the day.

Should it be decided to introduce grain feeding when the chicks are six weeks old, the chicks could be fed one of the mashes listed in Table 10 until they are six weeks of age and from the seventh week, whole grain feeding could be introduced as outlined in Table 12. If the chicks have free access to the mash (as they should to a dry mash) they will consume the approximate amounts of mash that are given in Table 12. The information given in Table 12 also covers the feeding of chicks 13-22 weeks of age under this system.

At the 22nd week old stage the pullets should be within a fortnight of laying and they can then be given a laying ration which contains from 15.0 to 15.5 per cent. of protein. Under a mash-grain system of feeding it is recommended that each laying bird receives 2½ ozs. of a mash (either wet or dry) containing approximately 18.3 per cent. of protein and 1½ ozs. of wheat per day. The fowls' diet would then contain 15.2 per cent. protein.

$$2\tfrac{1}{2} \times 18.3 = 45.75$$
$$\frac{1\tfrac{1}{2}}{4} \times 10 = +15.0$$
$$4)60.75$$
$$15.2 \text{ approximately}$$

Providing the wheat is restricted to 1½ ozs. per bird per day (approx. 9½ lb. per 100 hens), the birds will automatically eat about 2½ ozs. of mash. It is assumed that laying birds eat 4 ozs. of mash and grain per day. Should heavy breed hens or very high producing hens eat slightly more, say 4½ oz. per bird per day, then if the level of wheat is fed at 1½ oz. per bird per day, the slightly higher proportion of mash eaten will result in these birds receiving a higher protein ration, i.e. one which contains approximately 15½ per cent. of protein, which is quite reasonable as the extra eggs produced would require more protein.

$$3 \times 18.3 = 54.9$$
$$\frac{1\tfrac{1}{2}}{4\tfrac{1}{2}} \times 10.0 = 15.0$$
$$4\tfrac{1}{2})69.9$$
$$15.5$$

THE FEEDING OF CHICKS UNDER A MASH-GRAIN SYSTEM OF FEEDING.

TABLE 12.

Age in Weeks.	Parts of Mash by Weight.	Parts of Grain by Weight.	Per cent Crude Protein content of Total Ration.	Pounds consumed per week by 100 LIGHT BREED pullet chicks.				Pounds consumed per week by 100 HEAVY BREED pullet chicks.			
				Mash.	Grain.	Total.	Approx. No. of lb. of grain (10% protein) fed to 100 chicks per day.	Mash.	Grain.	Total.	Approx. No. of lb. of grain (10% protein) fed to 100 chicks per day.
1–6	All Mash	....	16	....	....	210	....	....	....	235	....
7th	9	1	15·5	58·5	6·5	65	1	72	8	80	1¼
8th	8	1	15·3	64	8	72	1⅛	85	10	95	1½
9th	7	1	15·25	70	10	80	1¼	90	15	105	2
10th	5	1	15·0	75	15	90	2	88	22	110	3
11th	4	1	14·8	76	19	95	2¾	85	30	115	4¼
12th	3	1	14·5	81	27	108	4	90	30	120	4¼
13th	2	1	14·0	74	36	110	5	80	40	120	6
14th	2	1	14·0	74	36	110	5	83	42	125	6
15th	2	1	14·0	76	38	114	5½	87	43	130	6
16th	2	1	14·0	78	39	117	5½	90	45	135	6⅓
17th	2	1	14·0	80	40	120	5¾	90	45	135	6⅓
18th	2	1	14·0	80	40	120	5¾	93	47	140	6¾
19th	2	1	14·0	82	41	123	6	93	47	140	6¾
20th	2	1	14·0	84	42	126	6	97	48	145	7
21st	2	1	14·0	84	42	126	6	97	48	145	7
22nd	2	1	14·0	84	42	126	6	97	48	145	7
Total	....	....	....	1,220·5	481·5	1,912	....	1,417	568	2,220	....

N.B.—The quantities of food eaten by different batches of chicks of the same age, sex, breed and number are by no means constant. The figures in Table 12 are not the result of any particular experiment but merely approximate figures showing the average amounts of food that would be eaten per week if a large number of chickens were used. It is interesting to note that in actual experiments, the food consumed by 100 chicks for any particular week is sometimes less than that consumed by the same chicks during the previous week of the test.

Should it be intended to feed a wet mash to the birds during their laying period, it is usual to commence feeding a wet mash when chickens are eight weeks old. This wet mash is in addition to the dry mash and can contain the same ingredients as the dry mash and in the same proportions. Usually two fifths of the wet mash by volume consists of finely cut greens. The mixture can be damped with water or preferably with skim milk. The chickens should eat the amount given them within 20 minutes. Once wet mash feeding is commenced it should not be discontinued. At the present time there is a swing throughout the poultry industry of Australia from a wet mash-grain system of feeding to an all dry mash feeding system. The change is viewed favourably by this Department.

From the time the chickens are one week old, finely-cut succulent greenstuff should be fed once a day. Insoluble flinty grit (e.g. fine granite or gravel) should be before the chicks at all times. This is particularly important during the first week of the chicks' life as the presence of grit in the gizzard aids considerably in the digestion of the food. Shell grit is not necessary providing the mash contains sufficient calcium. The optimum calcium level in the mash is easily obtained by the inclusion of a small amount of bonemeal, and in the chick rations given in this article (Table 10), provision has been made for the calcium in the mash. Plenty of fresh clean water should be before the birds at all times.

FEEDING LAYING HENS.

Mashes suitable for feeding to laying hens under an all mash system are given in Table 13.

TABLE 13.

Ingredient.	Ration.					
	1.	2.	3.	4.	5.	6.
	lb.	lb.	lb.	lb.	lb.	lb.
Bran	30	20	10	30	....	26
Pollard	....	10	10	30	....	20
Crushed Wheat	42	37	50	15	80	36
Gristed Oats	20	20	20	15	....	10
Blood Meal	....	....	....	....	....	2
Meatmeal (50% Protein)	10	11	13	8	15	6
Buttermilk Powder	2	....	....	....	....	1
Bonemeal	3	3	3	3	2	3
Oyster Flour	3	3	2	3	2	3
Total	110	104	108	104	89	107

In addition to the mashes listed above many other mashes are suitable for feeding to laying hens, and the mashes listed serve only as a guide to demonstrate that various ingredients can be used in different proportions without materially changing the nutritive value of the mash. The availability of the different feeding stuffs to those engaged in the poultry industry varies considerably. A farmer who has difficulty in obtaining mill offal has to make greater use of gristed grains in laying mashes. This can usually be accomplished quite successfully if the farmer realises that the grain contains a lower protein content than mill offal, and adds more meatmeal to compensate for this.

The following principles should be kept in mind when compounding a mash:—

1. The first aim should be to obtain a 15-15½ per cent. protein level in the mash (all mash ration). Meatmeal and dried buttermilk powder are the most common protein-rich foodstuffs, used to balance the low protein-containing foodstuffs, such as gristed grains and mill offal. Mill offal being higher in protein than gristed grains, it is obvious that the higher the mill offal content of the mash the smaller the amount of meatmeal required. Compare ration 3 with ration 4, Table 13.

Ration 3 contains only 20 lb. of mill offal and requires 13 lb. of meatmeal in order to raise the protein level of the mash to 15 per cent.

Ration 4 contains 60 lb. of mill offal, and requires only 8 lb. of meatmeal to raise the protein level to 15 per cent.

Rations 1 and 2 both contain the same level of mill offal and have the same protein content. Ration 1 contains 10 lb. of meatmeal in 110 lb.; and ration 2, 11 lb. of meatmeal in only 104 lb. Ration 2, however, unlike ration 1, does not contain buttermilk powder (30-35 per cent. protein) and therefore needs the extra meatmeal to attain the same overall protein level. Approximately 3 lb. of buttermilk powder are required to replace 2 lb. of meatmeal (50 per cent. protein). Buttermilk powder is not absolutely essential in a laying hen's diet, but where no other riboflavin-rich foodstuff is fed, buttermilk powder should be included at a 3½ per cent. level in the ration fed to breeding hens. Otherwise rations which are suitable for laying hens are also suitable for breeding hens.

2. Bran and pollard have approximately the same nutritive value so that from this point of view the relative proportions in which these two materials are included in the mash does not matter to any extent. The question of palatability does, however, arise, and in order to keep the mash open in texture, it is recommended that the weight of pollard should not exceed the weight of bran to any extent.

3. If necessary, wheatmeal (crushed or gristed wheat) can comprise up to 80 per cent. of the mash, but gristed oats, because of their high fibre content, should form not more than 30 per cent. of the mash. The inclusion of oats at lower levels than 30 per cent. will, however, improve the nutritive value of the mash.

4. Three per cent. each of bonemeal and oyster flour will ensure an adequate calcium and phosphorus content in most mashes.

Feeding Grain with the Mash.

When grain feeding is restricted to 1½ oz. per bird per day (9½ lb. per 100 birds per day), 12 lb. of meatmeal, 3 lb. of bonemeal and 2 lb. of oyster flour should be added to the different total quantities of the mashes listed in Table 13.

These amounts of meatmeal, bonemeal and oyster-flour are necessarily added in order to maintain a satisfactory level of protein, phosphorus and calcium; namely 15 per cent., 1 per cent. and 2.3 per cent. respectively over the total food intake.

Rations for Breeding Hens.

The nutritional requirements of breeding and laying hens are very similar but not identical insofar as the breeding hens' requirements for two vitamins (namely riboflavin and Vitamin A) are higher than the laying hens' requirements for these nutrients. Normal levels of greenfeed will provide breeding hens with sufficient Vitamin A, but when fish oils are used to provide Vitamin A, extra amounts of the oil have to be fed (see Table 4).

To ensure good hatchability and strong chicks it is important to see that the breeders receive adequate riboflavin in their diet. The rations listed for laying hens in Table 13 do not contain sufficient riboflavin for breeding hens, but by adding 1½ lb. of buttermilk powder to ration 1, and 2½ lb. to ration 6, and 3½ lb. to rations 2-5 inclusive, the riboflavin content would be increased sufficiently to meet the breeding hens' requirements when on an all-mash system of feeding. Where buttermilk is not available use an extra half pound of whey powder on these quantities.

Should grain (1½ ozs. per bird per day) be fed in addition to mash then add 2 lb. of buttermilk powder or whey powder to the amounts given in the previous paragraph. When using whey powder add the required amount to the mashes listed, but when using buttermilk powder, 2 lb. less meatmeal can be used for every 3 lb. of buttermilk powder used and the protein content of the ration will be maintained.

FEEDING MOULTING AND BROODY HENS.

Moulting and broody hens have one feature in common. They do not lay eggs. Both phases are rest periods in the life of the fowl as far as egg production is concerned and the aim of the flock attendant in dealing with birds in either of these two conditions should be to bring the birds back into production as quickly as possible. The only way to do this to feed the fowls a ration which contains nutrients in sufficient amounts and of proper quality for egg production; in other words, the same ration that would be suitable for hens actually in production. The practices of feeding moulting and broody hens low protein diets, which in some cases consist only of grain, and of starving the birds are completely unscientific and cannot be too strongly condemned.

In order to obtain eggs for hatching from second year birds in July, it is necessary for the birds to commence laying in June, and to accomplish this, the farmer has very often to force his late moulting first year birds into a moult during March. This can be accomplished by eliminating the protein rich foods (meatmeal and buttermilk powder) from the diet. One or two weeks' feeding on a ration which contains no meatmeal will accomplish this. Sometimes only grain is fed. Once the birds go into a moult, however, normal feeding (ration suitable for laying hens) should be immediately restored. The nutritional requirements of hens for feather growth are for all practical purposes the same as those for egg production.

ARTIFICIAL LIGHTING.

The artificial lighting of laying sheds in countries such as England and Canada where long nights and short days are experienced is a very common practice and the extra eggs laid more than pay for the expenses incurred in installing and maintaining the lights.

Artificial lighting is not particularly common in Western Australia but some farmers do employ lights to advantage.

Although there is no experimental evidence available on this subject in Western Australia it seems highly probable that the use of lights during May, June, July and August would be warranted.

The best developed chickens seen by the writer this season were chickens that were subjected to artificial light at night; and which were thereby encouraged to eat for a full 24 hours each day. On one farm more than 1,200 chicks were subjected to lights throughout the night. These chicks showed good even development, were vigorous and had an exceptionally low mortality rate.

In a poorly lighted brooder house in the depth of winter, chickens spend from 5 p.m. in the evening until 7 a.m. the next morning under the brooder—a period of 14 hours each day out of 24 hours. This state of affairs automatically restricts the chickens' food intake, and the use of electric lights in the brooder house, even if only for five or six hours each night, would help to enable the chickens to eat that quantity of food which is necessary to ensure the fast growth rates desirable in chickens one to six weeks of age.

The use of electric lights in laying sheds would also seem sound practice during the winter months. Birds that are just coming in to the lay in May require all the food they can possibly eat to enable them to produce extra eggs which at that time of the year represent greatly increased income because of the egg scarcity and consequent high price. A flock (White Leghorn pullets in particular) will often commence laying in March or April and give only a moderate lay until July when they begin to make a forward move. It is possible that if slightly greater quantities of food were consumed during the early winter months, higher egg production would follow. Also even when fowls are producing at a generally accepted satisfactory level during August, it is possible that more economical egg production would result if the hens were given artificial lighting, as even a five per cent. increase in production during August represents a higher income. One big scale poultry farmer in Western Australia arranges for the electric lights to be automatically switched on at 4 a.m. in his laying sheds during the winter months, and claims this to be sound practice. Immediately the lights come on the fowls make for the dry mash hoppers. When their crops are full they then become interested in the nests.

FATTENING.

Present day meat prices for prime poultry are an incentive to producers to market their birds in good condition, and numerous enquiries have recently been received in connection with the production of prime cockerels. There is little benefit to be gained from attempting to "finish for market" a cockerel that is not well grown. The art of fattening is not to deposit solid masses of fat in various parts of the bird's body, but rather to infiltrate small globules of fat throughout the body of the bird and in particular throughout the muscle or meat. Fatten-

ing is a "topping off" process and to be successful, it must be carried out on a well grown, thrifty bird that has been reared on a good "starter ration" as a young chicken, and on a good "growing ration" subsequently.

Little benefit will be gained from attempting to fatten birds that are less than 17 weeks of age. Until the birds are 17 weeks old the aim should be to keep them growing by feeding sufficient protein in the diet for this purpose. The aim to this age should be to produce flesh and not fat. However, if it is intended to market the birds when they are 20 weeks of age, a fattening ration (low protein diet) could be fed at 17-18 weeks. At this time the growth rate has slowed down sufficiently to insure that the fat derived from the fattening diet is deposited in between the muscle or meat with reasonable efficiency.

During the growing period the cockerels should be kept free of intestinal worms by dosing with Black Leaf 40 or Carbon Tetrachloride, and before being placed in the fattening coop they should be freed of all vermin.

In New South Wales the demand for cockerels 12-16 weeks of age is very good, but in Western Australia it is limited. In Western Australia cockerels are usually marketed when four to five months of age before the spurs begin to develop. Once the spurs become evident the birds are classed as "stags" and their value drops considerably. Cockerels intended for fattening should be fed a ration which is suitable for feeding to growing pullets, i.e. a 16 per cent. protein diet during the first six weeks of their lives and a 14 per cent. protein ration from the time they are 13 weeks old until two to three weeks before they are marketed, i.e., until the fattening period commences. (See Tables 10 and 11.)

During the fattening period a 12-13½ per cent. protein diet composed of a mixture of grains (principally) and mill offal, made into a wet mash or a gruel with skim-milk will give good results. Milk whitens and softens the flesh and is beneficial in a fattening diet. The wet mash can consist of one and a half parts by bulk of mash to half a part of skim milk and the gruel one and a half parts of mash (30 lb.) to one part of skim-milk (40 lb.). A suitable fattening mash to be fed with skim-milk, containing 10½ per cent. of protein, is as follows:—

Ingredient.	Weight.	Crude Protein.
	lb.	lb.
Wheat (Gristed)	60	6·0
Oats (Gristed)	20	1·8
Bran	10	1·4
Pollard	10	1·35
Total	100	10·55

This mash when made in a wet mash or a gruel as outlined above with skim-milk would give a 12 and a 13½ per cent. protein ration respectively.

Three feeds should be given daily. The gruel should not remain before the birds for more than 30 minutes at a time. Greenfeed feeding should be restricted to enable the birds to eat large quantities of mash. The birds will not suffer from a greenfeed deficiency in such a short time as two to three weeks, but a small amount of greenfeed, say one quarter the usual amount will help to keep the birds' appetites keen. Fish oils and fish meals should not be fed for two weeks prior to slaughter as they may taint the flesh.

Should skim-milk be unobtainable each 100 lb. of the above fattening mash containing 10½ per cent. of protein could have added to it 4 lbs. of meatmeal. This would increase the protein content of the mash to 12½ per cent. This mash could be made moist with water, or, providing the birds have been accustomed to dry mash feeding, it could be fed dry. The writer prefers dry mash feeding to all other methods of feeding, and cockerels intended for meat will develop well on dry mash feeding. To be successful, however, one cannot overstress the importance of rearing the birds on this method of feeding right from day-old.

If at the beginning of the fattening period it is desired to switch the birds over to a gruel from dry feeding, the birds should be given a wet mash for a few days, and then the wet mash can be made progressively more fluid until the consistency of a gruel is obtained. The birds will not appreciate a sudden change of the feed to a more fluid consistency, but a gradual change will meet with success.

During the "topping off" period the birds should be confined. A coop is preferred, but is not always available. Fattening birds are therefore sometimes housed in pens in groups of 20 or 30 birds and two square feet of floor space is allowed each bird. The smaller the group the more successful the fattening. Under this method of housing, where there is a possibility of the birds standing in the food troughs, it is more practical to feed a wet mash than a gruel. Fattening birds with a limited run may be given the fattening mash for three weeks prior to marketing without losing their appetites, but birds that are closely confined in a coop after being accustomed to free range usually lose their appetites after a fortnight's confinement. Great skill is required to feed for best results, and the feed should be removed just before the birds have eaten enough. If at any time the birds go "off-feed," one feeding should be omitted. Clean troughs will help to maintain a healthy appetite.

A suitable coop capable of holding six birds would be one three feet deep, three feet high and two feet wide. The coop should have a slatted bottom (slats 1½ inches apart) and be off the ground to allow the droppings to pass through. The front should be slatted (slats 2½ inches apart) to enable the birds to eat from troughs arranged along the front of the coop. It is important that the fattening coop be placed in a cool, sheltered, quiet position where the birds will not be unduly disturbed.

In rearing cockerels for meat purposes it is important to realise that satisfactory development will only be obtained if the cockerels are grown during the cooler months of the year. Cockerels for this purpose can be hatched from March until August inclusive.

N.B.—It is not recommended that pullet chicks for egg-production be hatched as early as March. July and August are the two months considered most suitable for hatching chickens intended for egg-production.

Oestrogens for Fattening Poultry.

Although the practice has been forbidden in Canada it is interesting to note that several oestrogens have been successfully used to fatten poultry on an experimental scale. The use of these oestrogens cannot be recommended to the poultry farmer because of the possibility of these hormones having an adverse effect on human beings eating birds that have been treated.

The production of table birds has essentially two features.

In the first place meat in the form of muscle must be laid down as quickly and as efficiently as possible. The protein content of the growing ration should therefore be adequate for this purpose. Having built up a good body it is necessary to fatten it. The fattening process is the infiltration of the muscle layers with fat, to give that juicy tenderness which is so much appreciated at the dinner table. The feeding of oestrogens or the implanting of oestrogens under the skin of fattening birds has been claimed to accelerate this process. The hormones apparently have a depressing effect on the bird's metabolic rate, and the reduced muscular activity allows of more rapid fat deposition.

Of the artificial hormones which have been experimented with Diethylstilboestrol (implanted under the skin,) (Lorenz 1945, Poultry Science) and diethylstilboestrol dimethyl ether (mixed with the food) (Japp and Thayer 1944, Poultry Science 23, 249) appear to have given the best results. Also refer to the paper read on 'The influence of sex and hormones on growth and fattening of chickens" by R. George Japp at the Eighth World's Poultry Congress, Copenhagen, 1948.

CANNIBALISM.

This vice is quite common in Western Australia amongst both adult and young stock. It usually first appears in a mild form. However, its incidence will increase and heavy losses will be experienced unless steps are taken to control it.

Although deficiencies in the diet can cause cannibalism it is probable that the chief cause of the vice in this State is that of over-crowding (including insufficient nesting accommodation—one nest should be allowed to every four hens). The farmer should first satisfy himself that over-crowding is not the cause of the trouble before investigating the possibility of a nutritional deficiency. As chicks develop and grow they require more eating, drinking and running space. These are not always provided and cannibalism often results. Cannibalism is less likely to occur amongst chickens which have a roomy well grassed run.

Idleness will often lead to cannibalism. Conditions which exist under a system of all-grain feeding of fowls from hoppers, with no litter for the fowls to scratch in, and a limited area for the fowls to roam in, may initiate feather picking, and consequent cannibalism

From a dietary aspect three deficiencies in the rations may be responsible for cannibalism and these are:

1. Protein.
2. Salt.
3. Bulk.

1. Fowls which are receiving a low protein diet (particularly one lacking in meatmeal) and which develop vicious habits should have their meatmeal intake increased.

2. Increasing the common salt content of the mash in an all mash ration to two per cent., and in a mash-grain ration to three per cent., has in some cases accomplished the desired results in other countries. The normal level of salt feeding should however be restored as soon as the condition is corrected.

3. Because of their high fibre content, (bulkiness) oats have been claimed by many as being useful in controlling outbreaks of cannibalism, and the inclusion of oats at a 30 per cent. level of the total feed intake could be tried.

This is another point in favour of feeding an "open textured" mash to poultry. A shortage of greenfeed may also result in cannibalism. Success in controlling outbreaks of cannibalism amongst chickens has been claimed in other parts of the world by using red cellophane screens over the brooder house windows. In this way a red tint is given to the whole of the chick and the red vents are rendered inconspicuous.

It seems certain that cannibalism is inherent and that some strains and breeds are more disposed towards cannibalism than others. In this State cannibalism is more apparent in White Leghorns than in the heavy breeds. Sometimes one or two birds in a pen may have cannibalistic tendencies and if these birds are removed before they have had time in which to teach other birds in the pen the vice, the trouble will stop. Injured birds should be isolated, and wounds caused through picking should be treated with a dilute disinfectant.

Light aluminium guards which fit over the uper beaks of birds with cannibalistic tendencies have been used with a certain amount of success to reduce the incidence of vent picking amongst laying flocks in the Eastern States of Australia.

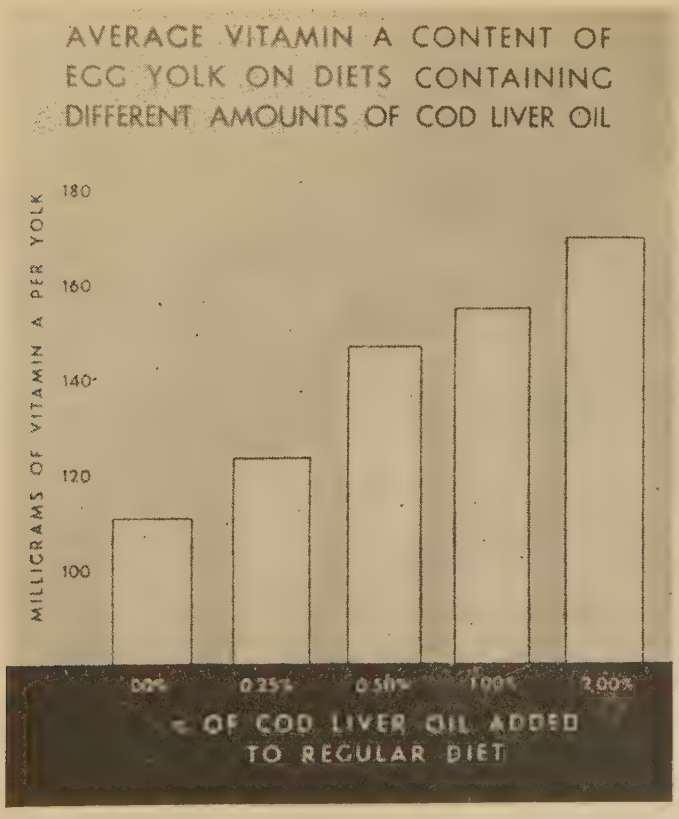


Fig. 20.

Less vitamin "A" means less nutritious eggs.

THE EFFECT OF THE COMPOSITION OF THE DIET ON EGGS.

The egg is an excellent item of diet for human beings, and it is interesting to note that the nutritive value of an egg can be made to vary according to the foods which are given to the hen. Some of the ways in which the hen's diet can affect the composition of her eggs are as follows:—

1. Dict may affect the percentage of protein in both yolk and the white of an egg, but not the composition of the constituent protein.

2. Diet may affect both the percentage of fat in the yolk and the composition of the fat.

3. The quantity of Vitamins A and D in the egg may be made to vary over quite a wide range by varying the quantity of these vitamins in the diet.

4. Under experimental conditions the quantities of Vitamins B1, E and of B2 (Riboflavin) in eggs have been influenced by diet.

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ZINC FERTILISERS FOR SUBTERRANEAN CLOVER AT KENDENUP.

By T. C. Dunne and H. G. Elliott.

LAND in the Kendenup and surrounding districts, cleared of timber in the last few years with a view to development for agricultural purposes, was intended to carry midseason (Mt. Barker) subterranean clover (*T. subterranean*) as the basic pasture species. It was found, however, that in spite of liberal manuring with superphosphate satisfactory subterranean clover pastures were not always developed.

Growth of clover has often appeared reasonably satisfactory, though by no means luxuriant, in the year of establishment but subsequently productivity has been poor. Some unthrifty plants showed the small leaves and rosetted appearance believed to be typical of zinc deficiency. Plants, however, made sufficient growth to develop a thin sward 1-2 inches high but the plants themselves still had a stunted appearance associated with leaves of a dull yellow colour in which brown dead areas were often found.

Fig. 1.

A comparison of subterranean clover growth in two plots.
On left—superphosphate.
On right—superphosphate plus zinc oxide.

FIELD EXPERIMENT.

It was decided in 1949 to conduct a simple trial on the property of Mr. W. Frost at Kendenup, in an effort to determine whether a deficiency of one of the elements, copper and zinc, which had given growth responses elsewhere in Western Australia, was responsible for this unsatisfactory growth.

The area selected originally caried stunted jarrah (*Eucalyptus marginata*) and red-gum (*E. marri*) trees. The surface soil was sandy, intermixed and underlain with gravel and a few boulders of iron-stone gravel were exposed. Clearing opera-

tions had been carried out with the aid of a bulldozer in 1945 and seeding with mid-season subterranean clover done in 1946. Superphosphate at the rate of 1 bag (186 lb.) per acre was applied at the time of seeding and subsequently each autumn until 1949.

In June 1949 the following fertiliser treatments were applied to the selected area.

A. Superphosphate—168 lb. per acre.
B. Superphosphate—168 lb. plus copper ore (10% Cu.) 12½ lb. per acre.
C. Superphosphate—168 lb. plus zinc oxide 4 lb. per acre.
D. Superphosphate—168 lb. plus copper ore 12½ lb., plus zinc oxide 4 lb. per acre.

Each fertiliser treatment was applied to two plots, each ¼ acre in extent, during June, 1949.

Fig. 2.
An example of the pasture produced with zinc oxide.

The light coloured patch in the right hand lower corner and those in the background are typical of the yellow clover cover previously characteristic of the paddock.

RESULTS OF EXPERIMENT.

Excellent improvement in growth was obtained on those plots which received zinc oxide. By mid-July, the district officer, Mr. Tobin, was able to discern better colour in the plants which had received zinc. By the end of July, growth differences were also apparent. Thereafter the zinc plots developed a luxuriant cover of subterranean clover plants with leaves up to 1½ inches across. The remaining plots made little better growth than the headlands which had not received any fertiliser dressing. The improvement in growth obtained is illustrated in Fig. 1. while Fig. 2. illustrates the type of pasture obtained with the aid of zinc oxide.

OTHER FIELD RESULTS.

Acting upon the suggestion that zinc deficiency might be responsible for the poor growth of clover noted, Mr. Frost topdressed the remainder of the field in which the experiment was located with a superphosphate-zinc mixture by means of which zinc sulphate at the rate of 5½ lb. per acre was applied. A heavy crop of clover similar to that produced on the experiment plots was obtained by this treatment.

Zinc was also used on portions of a recently cleared area seeded for the first time. Here again excellent growth of midseason subterranean clover was obtained only where zinc sulphate was applied. On a flat previously carrying Yate (*E. occindentalis*) trees, midseason and "Yarloop" (white-seeded) subterranean clover failed in the absence of zinc but drooping flowered clover (*T. cernuum*), suckling clover (*T. dubium*) and Wimmera rye grass (*Lolium rigidum*) made excellent growth. It seems likely that these latter species have a lower zinc requirement than the subterranean clovers used but it is by no means certain that the satisfactory first year growth will be maintained.

CONCLUSION.

It is obvious from observations made on various properties in the Kendenup district that satisfactory establishment and growth of midseason subterranean clover cannot always be obtained on newly cleared land by manuring sown pastures solely with a reasonable quantity (1 bag per acre) of superphosphate.

The data reported show that excellent growth can be obtained by the application with superphosphate of either zinc oxide or zinc sulphate. When used at the rates reported, zinc oxide supplied much more actual zinc than did the zinc sulphate. There still remains to be determined the optimum rate of application of zinc and residual effect from year to year of the zinc applied.

It is appreciated that in the past many satisfactory pastures were established in the Kendenup district without the use of zinc fertilisers. Whether or not this was due to the fact that pre-war superphosphate manufactured from Nauru Island rock contained three to four times as much zinc as the present superphosphate, for which Christmas Island rock is used, is speculative but warrants investigation. Whether, too, the production of older established pastures could be improved by the use of zinc fertiliser remains to be proven.

SUMMARY.

An unhealthy condition of midseason subterranean clover plants characterised by dull yellow leaves, often with necrotic areas and sometimes characterised by rosetted plants is reported.

In field trials this condition has been overcome and luxuriant growth produced by the use of zinc fertilisers, either as zinc oxide or zinc sulphate.

ACKNOWLEDGMENT.

Acknowledgment is made of the assistance of Mr. W. Frost and of Mr. C. Tobin in the conduct of the trials reported in this paper.

REGENERATION OF A SUBTERRANEAN CLOVER PASTURE WITH MOLYBDENUM.

By T. C. Dunne.

THE effect of molybdenum in improving the growth of subterranean clover was first reported by Anderson (1) in 1942 following his successful experiment on iron-stone soils in South Australia. Subsequently Teakle (4) tested the value of this element at a number of sites in Western Australia, but only in one instance did there appear to be any benefit.

During 1947 it was suggested that the symptoms on unhealthy clover on a field seen at Donnybrook resembled those of molybdenum deficiency as observed in South Australia. The soil under consideration, which was a clay loam, had supported a fair growth of *Phalaris tuberosa*, but in spite of the introduction of a number of legume species in 1944, only a small amount of subterranean clover had persisted.

FIELD EXPERIMENT.

Arrangements were made to apply a molybdenum fertiliser on this area. In addition for various reasons, it was considered advisable to test the effect of zinc. The three treatments used were:—

1. Roasted molybdenite (55 per cent. molybdenum) 4 oz. per acre.
2. Zinc sulphate (25 per cent. zinc) 10 lb. per acre.
3. Roasted molybdenite 4 oz. per acre plus zinc sulphate 10 lb. per acre.

The mixtures were applied in strips across the field at the beginning of September, 1947, each strip comprising ¼ acre. In subsequent years only superphosphate was applied.

RESULTS OF EXPERIMENTS.

No benefit from any of the treatments was noted during the remainder of 1947 or during the 1948 season. However, striking changes were observed in 1949. The strips which had received molybdenum had developed a thick mat of pasture. While *Phalaris* appeared to have been invigorated, the molybdenum treated plots were in the main dominated by large leaved subterranean clover plants. By contrast, the clover which had persisted in the remainder of the field showed spindly growth and had small thin yellow leaves. The untreated areas carried some *Phalaris*, but the cover consisted mainly of the annual silver and brome grasses.

The effect of molybdenum in changing the botanical composition of the pasture from grass to clover dominance is shown in Fig. 1. The vigorous type of clover growth obtained is illustrated in Fig. 2.

Fig. 1.

A comparison of normal cover of the paddock (foreground) with the clover sward (background) developed by the use of molybdenum.

DISCUSSION.

It has been shown by the later work of Anderson and Thomas (2) that the pale green or yellow colour typical of molybdenum deficiency is due to an actual deficiency of nitrogen within the plant. Molybdenum is necessary to enable the bacteria contained in the nodules of legumes to fix nitrogen. Even though nodules may be plentiful on the roots of the clover, no nitrogen is fixed in the absence of a sufficient supply of molybdenum.

Another point of importance is that, within any soil, the less acid the soil becomes, the more molybdenum becomes availab'e. It is well known that lime is used to lessen or reduce the acidity of soils. It is, therefore, of interest in connection with the field in which the trial was conducted, to note that in 1944, lime was applied in a strip across the area and that better growth was temporarily obtained on that strip. It is quite likely that the effect of lime was to increase the availability of molbydenum and thereby improve growth. It should be realised, however, that except on very acid soils, it is much better to apply the few ounces of molybdenum fertiliser necessary than to dress with lime for the purpose of overcoming molybdenum deficiency.

In the trial reported, roasted molybdenite, which is a relatively insoluble form of molybdenum, was used. It is possible that a more soluble form such as sodium molybdate may have given a more rapid response to treatment, but this remains to be proven. Other areas on which the clover shows signs of molybdenum deficiency have been located and it is intended to conduct further experiments to determine the values of the various forms of molybdenum fertilisers and to decide the most suitable rates of application.

SUMMARY.

An account is given of the effect of molybdenum fertiliser in regenerating a declining subterranean clover pasture and in promoting vigorous growth.

Phalaris tuberosa was benefited slightly by the application of molybdenum.

Fig. 2.

Illustrating the vigorous type of clover growth obtained with molybdenum.

Photo: A. Sharp.

ACKNOWLEDGEMENT.

Field supervision since 1944 has been done by various officers of the Dairy Branch of the Department of Agriculture. Thanks are also due to Mrs. M. C. Fry and Sons for continuous interest in the trials.

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WHEAT VARIETY TRIALS ON RESEARCH STATIONS.

I. Thomas, Superintendent of Wheat Farming and E. R. Watson, Agricultural Adviser.

THE development of wheat varieties suited to Western Australian conditions has played a very important part in the extension of the wheatbelt. Since Farrer first commenced his crossbreeding programmes with the ultimate aim of producing varieties more suited to local conditions wheat varieties have been improved in many respects. The result is that today a farmer usually has the choice of a number of varieties which are disease resistant, yield well under a wide variety of soil and climatic conditions and produce grain of good milling quality. Although the plant breeder, in endeavouring to produce a new variety must give due consideration to disease resistance, flour quality and such characteristics as straw strength, ease of stripping, absence of shedding etc., he must also be certain for the success of the new variety that it measures up to the farmers "yardstick" of yield in bushels per acre.

To combine in one variety the better qualities of the two parents it is necessary to raise large numbers of the earlier generation crossbreds. The selection of the higher yielding "lines" was originally dependent on the skill of the plant breeder and most of the high yielding varieties grown today owe their existence to the personal skill of the breeder concerned. In the earlier days of plant improvement it was possible to expect rather wide differences and many of the new varieties produced were capable of out-yielding by large margins the variety which they were designed to replace. It is anticipated, however, that, in the future, increases in yielding ability will be relatively smaller and increasingly harder to detect.

Prior to the development of small scale ("micro") yield trials it was necessary for the plant breeder to carry a large number of crossbred lines through sufficient generations before he had enough seed to enable him to include them in the large scale yield trials. With the use of the small scale trials however it is possible to eliminate much sooner a large number of the less desirable crossbreds in the earlier generations. The crossbreds which give promising results in these trials, provided they are satisfactory in all other respects, are included in the larger field trials.

Promising new varieties produced in other states are also included in the large scale field trials to compare them with local varieties under conditions in this State. In all these trials the two standard varieties Bencubbin and Bungulla are used as controls. The value of using a well known variety as a comparison with others will be appreciated by the farmer as a very useful gauge of the actual worth of the varieties under trial. For the past six years over 50 per cent. of the total area planted to wheat in this State has been sown to these two varieties.

DISEASE RESISTANCE.

Flag Smut.

This disease is no longer regarded as being of great importance due to the very effective control given by resistant varieties. It is anticipated however that in the event of large areas being sown to varieties susceptible to this disease it would eventually reach epidemic proportions again. Whereas most varieties at present grown to any extent have a high degree of resistance to flag smut it is unfortunate that the variety Gabo is susceptible to this disease. This variety was used in another State as a rust resistant parent in a number of back-cross programmes but the back-cross varieties produced although resistant to rust also have a degree of susceptibility to flag smut.

Stem Rust.

Prior to 1942 the variety Eureka had a high degree of rust resistance in all States in Australia. In that year a new race of rust was isolated in New South Wales which was capable of attacking Eureka and all derivatives of it and its parent Kenya C6040. The varieties deriving their resistance from C6042 retained their resistance and were grown extensively, especially in the North-west of New South Wales where practically annual epidemics of stem rust occur.

In 1948, however, at least two new rust races were isolated in that area capable of attacking all varieties deriving their resistance from the Kenya C6042 parent, including the varieties Charter, Yalta, Kendee and Gabo. The latter variety was considered to possess the same type of rust resistance as Yalta, but it has since been shown that it possesses other sources of resistance which confer on it a degree of resistance to the new race complex although apparently not sufficient to warrant its recommendation as an entirely rust resistant variety. The variety Dowerin and its parent Kenya C6041 are still resistant to all races of stem rust in Australia.

In Western Australia, prior to 1949, there were no definite isolations of the Eureka attacking rust. In that year however, isolations made on Eureka at Toompup were sufficiently definite to indicate its presence in this State. This race was previously described as a biotype of race 34 but a revision of the classification has changed the latter to 126 while the biotype is now designated 126B. In the event of the suspected isolation of race 126B at Toompup being confirmed Eureka and its derivative variety Wongoondy will no longer be regarded as rust resistant here.

The new race complex isolated in New South Wales in 1948 referred to above has not as yet been isolated in this State and bearing in mind the lapse of time (1942-1949) between the appearance of race 126B in New South Wales and in Western Australia it is anticipated that the varieties Charter, Gabo, Kendee and Yalta will retain their resistance under our conditions for some years.

FLOUR STRENGTH.

For many years it appeared to be unfortunately true that it was impossible to breed a variety of wheat which combined high yielding ability with good grain quality. Within recent years however, a number of varieties have been produced which are satisfactory in both respects. These include Eureka, Wongoondy, Yalta and Gabo.

The inherent capacity of the variety to produce high quality grain can be markedly influenced by the conditions under which the crop is grown. A variety is not able to express the true value of its grain quality unless soil fertility is maintained. The farmer may not be directly concerned with the flour quality of the wheat he is producing but by the growing of varieties which will assist in the raising of the State f.a.q. he is indirectly able to influence the price obtained per bushel.

TABLE I.

RAINFALL RECORDS FOR RESEARCH STATIONS, 1949.

Station.	Year.	Jan.	Feb.	Mar.	Apl.	Growing Period Rainfall.							Nov.	Dec.	Total
						May.	June.	July.	Aug.	Sept.	Oct.	Total.			
Avondale	1949	....	49	8	49	13	157	228	227	65	37	727	130	1	964
Average	23 years	22	35	96	77	208	329	305	239	105	78	1,264	57	30	1,581
Chapman	1949	....	65	18	91	34	127	442	330	185	109	1,227	98	36	1,535
Average	44 years	25	38	65	76	226	418	390	263	145	89	1,531	40	26	1,800
Merredin	1949	....	21	8	29	15	147	239	243	67	35	746	71	17	892
Average	39 years	40	50	90	86	132	190	183	153	79	73	811	41	54	1,174
Salmon Gums	1949	13	19	13	2	84	64	233	216	135	178	910	142	117	1,216
Average	24 years	77	84	134	89	120	147	146	149	93	115	769	93	78	1,324
Wongan Hills	1949	27	33	34	37	12	202	341	219	86	69	929	89	2	1,151
Average	24 years	33	44	93	94	180	267	264	208	91	70	1,080	47	38	1,430

SEASONAL CONDITIONS AT RESEARCH STATIONS.

Conducting wheat variety trials on research stations in different areas enables the farmer to compare the results and to translate them into his own conditions. While it is not possible to conduct trials in each district the position of the different research stations is such that the results present a fair overall picture for the whole wheatbelt.

The seasonal conditions for 1949 varied considerably although generally a very late start and an early finish to the season was rather characteristic. The following is a brief summary of the seasonal conditions which prevailed at each of the research stations:—

Avondale.

Owing to an exceptionlly late opening of the season all seeding operations were carried out somewhat later than is considered desirable. Germination and early growth were however quite satisfactory as were subsequent growing conditions. Beneficial finishing rains were also received and as a result yields were above average.

Chapman.

As with the other stations the late opening of the season delayed planting operations considerably. Conditions generally during the growing period however were very satisfactory and with the best finishing conditions for some years yields of all crops were above average.

Merredin.

Although all crops were planted very late, growing conditions up to the end of August were very favourable and resulted in excellent crop growth. Excessively dry conditions prevailed from then onwards however and crops suffered severely and yields were well below average.

Wongan Hills.

Although the season opened late the fact that the majority of the crops including the variety trials were planted on new land enabled the bulk of the cropping to be carried out under good planting conditions. Despite a fairly long dry spell in the latter part of the season the crops made very satisfactory growth. Yields from the fallowed area were well above average.

Salmon Gums.

Crops at this station were sown under rather difficult conditions as rainfall was very spasmodic in the early part of the season. A dry spell experienced in September which affected the growth of the variety trials particularly was, however, relieved by good finishing rains.

RESULTS OF THE 1949 TRIALS.

The results of last season's trials are tabulated in Table II.

The experimental layout used for these trials is known as the randomised plot system. This system enables varieties to be compared directly with one another as well as with a standard or control variety of known yielding ability.

As soil type differs considerably even over a small area attention must be given to the layout of the experiment to ensure that apparent differences are not due to differences in soil or any such factor. For the purpose of comparing the yielding ability of two varieties it would not be sufficient to divide a paddock into two and sow half to each variety. A comparison of the yields obtained could give an incorrect comparison as no allowance would be made for the very great soil differences etc., which could occur within the paddock.

It has been found that the differences due to variety alone can best be measured by the use of randomised blocks of plots. Each variety is sown once in each of five blocks the position of the particular variety in each block being selected at random. The use of a number of replications increases the possibility of obtaining accurate data from the trial.

Even with such an experimental layout, due to such uncontrollable factors as soil variability etc., two adjacent plots sown on the one day to the same variety and with identical cultural treatments may not give equal yields. It is possible to calculate in bushels per acre for any correctly designed experiment the allowance which must be made for the uncontrollable factors. This figure and the corresponding percentage appear in the line "difference for significance P = .05."

If for instance Bencubbin yields 15 bushels per acre and another variety 10 bushels per acre and if the difference for significance is three bushels then it can be said that Bencubbin has significantly out-yielded the other variety. If, on the other hand Bencubbin had only yielded 2 bushels per acre more than the other variety then it could be assumed that the varieties were equal in yielding ability and that the two bushels difference in yield was due to soil variability or similar uncontrollable sources of variation.

TABLE II.

WHEAT VARIETY TRIALS AT RESEARCH STATIONS, 1949 50 SEASON.

	Avondale.			Chapman.			Merredin.			Salmon Gums.			Wongan Hills.		
	Yield.	Percentage of Control.		Yield.	Percentage of Control.		Yield.	Percentage of Control.		Yield.	Percentage of Control.		Yield.	Percentage of Control.	
		1949.	Average*		1949.	Average*		1949.	Average*		1949.	Average*		1949.	Average*
Early May Trials.															
	Bus. lb.	%	%	Bus. lb.	%	%	Bus. lb.	%	%	Bus. lb.	%	%	Bus. lb.	%	%
Bencubbin	15 50	100	100	18 13	100	100	....	....	....	15 41	100	100	21 54	100	100
Eureka	18 37	118	(6) 106	17 22	95	(6) 95	....	....	....	17 10	110	(6) 85	21 58	100	(5) 91
Kondut	17 23	110	(6) 106	16 18	89	(6) 95	....	....	....	14 59	96	(6) 85	20 45	95	(5) 87
Yalta	15 41	99	(2) 98	16 46	92	(3) 103	....	....	....	14 43	94	(2) 91	18 40	86	(2) 82
Celebration	13 42	87	(2) 94	12 27	68	(3) 81	....	....	....	12 51	82	(2) 83	18 46	86	(2) 80
Difference for Significance P = ± .05	2 52	18		1 16	7					1 11	8		0 41	3	
Late May Trials.															
Section I.															
Bungulla	15 47	100	100	20 46	100	100	7 12	100	100	17 10	100	100	20 6	100	100
Koorda	....	....	....	16 42	80	(5) 84	3 19	45	(5) 78	16 42	97	(5) 94	19 42	98	(5) 93
Frisco	....	....	....	15 57	76	(3) 86	6 4	83	(3) 100	....	....	....	20 33	102	(3) 95
Gabo	17 17	109	(3) 120	17 1	82	(3) 92	7 7	97	(4) 92	16 0	93	(3) 99	20 30	102	(3) 99
Kendee	18 37	118	(3) 117	17 34	85	(3) 90	4 11	57	(4) 80	15 28	90	(3) 98	22 26	112	(3) 101
Dowerin	16 22	104	(3) 111	12 45	61	....	3 57	54	(4) 84	15 44	92	....	18 26	92	(2) 87
Wongoondy	18 43	117	(4) 122	....	....	....	....	....	....	17 55	104	(4) 103	....	....	....
Difference for Significance P = ± .05				0 35	3		1 42	24		0 55	5		2 5	10	
Section II.															
Bungulla	....	....	....	21 10	100	100	8 6	100	100	....	....	....	17 44	100	100
Wongoondy	....	....	....	16 13	77	(4) 90	4 35	57	(4) 100	....	....	....	19 23	109	(4) 94
M88	....	....	....	20 54	99	....	4 45	59	(2) 80	....	....	....	17 15	97	....
M89	....	....	....	16 43	79	....	2 15	28	....	....	....	....	19 33	110	....
M90	....	....	....	19 12	91	....	5 1	62	(2) 83	....	....	....	17 52	101	....
M91	....	....	....	19 30	92	....	6 24	80	....	....	....	....	18 38	105	....
Difference for Significance P= ± .05				0 52	5		1 49	22					0 52	5	

* Number of trials indicated in parenthesis.

NEW VARIETIES.

Full descriptions have been given in a previous issue of this Journal (Vol. XXVI No. 1, March, 1949) and the following short notes refer to a discussion of the varieties based on the results of the yield trials.

Celebration.

The results obtained from a number of trials conducted for several years indicate that this variety has only average yielding ability and it is not anticipated that it will be recommended for growing in this State.

Frisco.

This variety which has a rust resistance similar to Eureka and Wongoondy has failed to yield well and will be discarded from future trials.

Gabo.

Although this variety has yielded consistently well at the Avondale Research Station it has failed to out-yield the standard variety Bungulla at the other stations. It is an early maturing variety that appears to need good finishing conditions to yield well. Unfortunately a serious disadvantage of the variety is that it is susceptible to flag smut.

Kendee.

This variety has the same type of stem rust resistance as Yalta. It has been included in trials for a number of years and except at the Avondale Research Station its yielding ability has not been up to expectation.

Yalta.

In view of its resistance to race 126B of stem rust its yielding ability and generally satisfactory agronomic characteristics, Yalta is now recommended as a rust resistant mid-season variety. It is considered to be superior to the variety Eureka which is susceptible to race 126B of stem rust now suspected as being present in this State.

Wongoondy.

This variety has continued to yield well under a wide variety of conditions and has yielded better than Bungulla at the Avondale Research Station and equal to that variety at Merredin and Salmon Gums Research Stations. During 1949 unfavourable climatic conditions at maturity caused a certain amount of shedding in some crops of Wongoondy and although this is undesirable it is a frequent occurrence in easy threshing strong-strawed varieties.

Dowerin.

The main value of this variety is that it is resistant to all known races of stem rust in Australia. Although its yielding ability is not exceptional it is appreciated that this variety would be very valuable in the event of a rust epidemic. It has yielded consistently well over three years trials at Avondale Research Station. The bulk plot at the Wongan Hills Research Station averaged 23 bus. 29 lb. per acre over approximately 30 acres in 1949.

Crossbred Varieties.

The crossbred varieties under trial M88, M89, M90 and M91 all have the Eureka type of rust resistance. In view of the suspected isolation of race 126B of stem rust at Toompup in 1949 and consequently the breakdown of the Eureka type of resistance in this State it is anticipated that these crossbreds will be eliminated from future yield trials.

STANDARD VARIETIES.

Bencubbin.

This variety still remains the most extensively grown variety in Western Australia and in 1948 was sown to over 30 per cent. of the acreage sown to wheat for all purposes. It has been replaced to a certain extent in the drier areas by the earlier maturing variety Bungulla.

Bungúlla.

The yielding ability of this variety has been proved over a wide variety of conditions while its early maturity has been of great value in the short seasons experienced. Like Bencubbin the straw tends to weakness and Bungulla should not be sown before the third or fourth week in May. It is sown to over 25 per cent. of the acreage making it the second most popular variety in this State.

Kondut.

This late mid-season maturing variety is well suited for the medium to heavy rainfall areas. It has yielded consistently well over a number of years and has won the State Championship award in the W.A. Flour Millowners Association cropping competition for the past three years (1947, 48 and 49). Kondut is a strong strawed variety which is highly resistant to flag smut but susceptible to stem rust. It is recommended for early plantings and its straw strength makes it very suitable for light lands.

Koorda.

This early maturing variety is very strong strawed and not liable to lodging which makes it particularly suitable for the lighter soil types. It is susceptible to stem rust but resistant to flag smut.

ACKNOWLEDGEMENTS.

Thanks are expressed to the managers and staff of the research stations for their assistance in conducting the above trials.

Stock Foods.

Additional Registrations under the Feeding Stuffs Act, 1928-1948.

Stock Food.	Reg. No.	Brand.	By whom Registered.	Materials from which Made.	Registered Analysis.							
					Crude Protein.	Crude Fat.	Crude Fibre.	Sodium Chloride.	Phos. Acid (P_2O_5).	Lime	Other.	
A.—SIMPLE FOODS.												
2.—*Meat and Bone Meals.*					% (Min.)	%	% (Max.)	% (Max.)	%	%	%	%
Meat and Bone Meal	153	"PENNELL'S"	Burridge-Warren Pty., Ltd.	Meat, bones	50.0	6.0	4.0	....	....	....	....	....
Do. do.	154	VITA MEAL....	Westralian Farmers Co-op., Ltd.	Meat and bone meal	40.0	7.0	2.0	....	....	....	....	....
Do do.	155	"TB&S (in diamond) BROOKLYN"	Thos. Borthwick & Sons (Aust.), Ltd.	Abattoirs offals	50.0	(max.) 12.0	4.0	....	....	....	....	....
4.—*Fish Meals.*												
Crayfish Meal	148	"CRAMEAH"	Industrial Waste Recovery	Crayfish	32.0	(min.) 0.5	10.5	....	2.0	CaO. 14.6	....	....
5.—*Milk Foods.*												
Buttermilk Powder	152	ROLLER	A. E. Hall & Co.	Liquid buttermilk	28.0	5.0	*Nil*	...	....	....	....	....
6.—*Wheat and By-Products.*												
Pollato	147	YORK FLOUR MILLING CO.	York Flour Milling Co.	Wheat	12.0	3.0	7.0	....	....	....	....	....
Stock Meal	146	do. do.	do. do. do.	do.	12.0	3.0	7.0	....	....	....	....	....
Branato	145	do. do.	do. do. do.	do.	12.0	3.0	7.5	....	....	....	....	....
B.—COMPOUND FOODS.												
2.—*Cattle Foods*												
12 per cent. Sweet Dairy Food	151	"THOMAS"..	W. Thomas & Co. (W.A.), Ltd.	Bran, wheat germ, branato, pea meal and/or malt combings, molasses, ground limestone, sodium chloride, techn. urea	12.0	1.5	8.5	2.0	....	(max.) Ca. 4.0	....	....
7.—*Pig Foods.*												
Pig Grower	150	"THOMAS"....	W. Thomas & Co. (W.A.), Ltd.	Bran, pollard, wheaten meal, meat meal, blood meal, bone meal, ground limestone, sodium chloride	14.5	2.50	6.50	2.0	....	4.5	....	....
Pig Starter	149	do.	do. do. do. Ltd.	Bran, pollard, wheaten meal, meat meal, blood meal, liver-meal, fish meal, bone meal, ground limestone, sodium chloride	15.5	2.5	6.5	2.0	....	4.5	....	....

URINARY CALCULI OF SHEEP IN WESTERN AUSTRALIA

H. W. Bennetts, Principal,

Animal Health and Nutrition Laboratory.

URINARY calculi or "stones," according to reports received by the Department of Agriculture during recent years, appear to be one of the most important causes of deaths in wethers and rams in the more Eastern Agricultural Districts.

An investigation of this problem was commenced towards the end of 1949 with the object of determining:—

(a) The types of calculi affecting sheep in these areas.

(b) The causes and mode of formation of the calculi.

(c) Ultimately if practicable, means of preventing the resultant losses from urinary obstruction, or "water belly," in rams and wethers.

The initial step was a survey of the region referred to in order to obtain information defining the problem, and to arrange for the co-operation of sheep owners in experimental work which has been planned for this season. In order to inform those interested of what is known, and what is being attempted a provisional account is given at this stage. This is based on published information from elsewhere, much of which has been reviewed by Beveridge (1942), and on data already collected in this State. Our understanding of the problem, however, is still very incomplete and no definite suggestions can yet be made regarding control.

This article is concerned primarily with urinary calculi occurring in the Eastern Agricultural areas where they constitute an important economic problem; the occurrence of calculi, however, is by no means restricted to this region.

Brief reference will be made, finally, to urinary calculi known to be associated with grazing on specific plants; to "clover stone" resulting from ingestion of subterranean clover and to those associated with grazing on Parakeelia (*Calandrinia spp.*) These are special cases where the main causal factor is known.

A GENERAL ACCOUNT OF URINARY CALCULI

1. *Occurrence.*

Urinary calculi have been reported from many countries. In England and America they are found most frequently in sheep being hand fed on a rich diet for show or for the market. In South Africa and Australia they are common in arid areas with a dry hot climate.

Reference will be made, later, to the circumstances of occurrence in this State.

2. *Symptoms.*

The presence of calculi in the kidney or bladder is not recognised until they pass on to cause partial or complete obstruction of the urinary tract, usually of the urethra (the passage conveying urine from the bladder to the exterior). In consequence their presence is not recognised in the ewe *during life*, as the larger more dilatable female passage permits of the animal passing them. In the male, particularly the wether, however, blockage of the narrow urethra is likely to occur at the urethral process, the sigmoid flexure or the ischiatic curve (see Fig. 1).

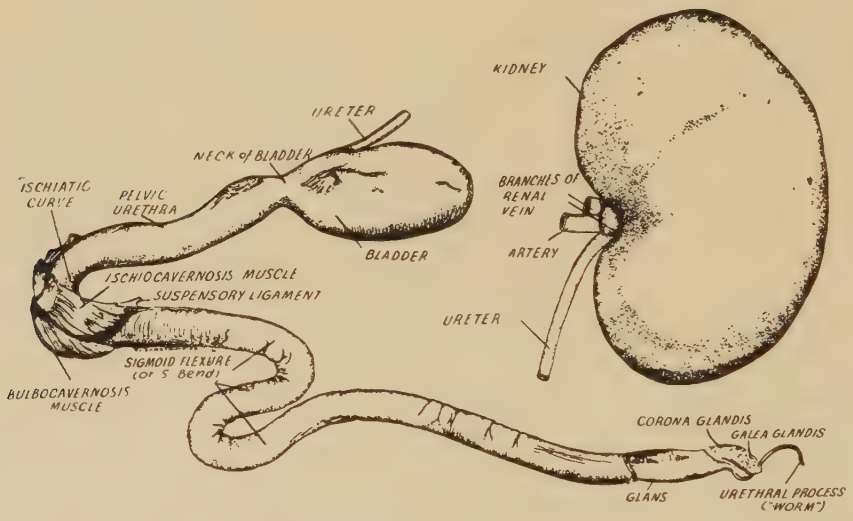


Fig. 1.

Semi-diagrammatic Sketch of Urinary Tract of the Male Sheep.

(Jour. Agric. Res.)

The first symptom is restlessness and occasional straining to urinate. The wool around the pizzle is nearly always wet and may be encrusted with salts. Later there is evidence of pain, the gait is straddled and the back arched. The bladder becomes distended with urine and ruptures within 48 hours of the stoppage. This is followed by distension of the abdomen and death within 24 hours to several days. In some cases the obstruction passes on before rupture of the bladder occurs in which case recovery is spontaneous, although the condition may recur due to the presence of further calculi.

3. *Post Mortem Appearances.*

Following rupture of the bladder the body cavity contains a large quantity of blood-stained fluid. The bladder and urethra are inflamed. The obstructing calculi may be found in the sites mentioned. They may also be seen in the bladder, kidneys or sometimes in ureters (see Figs. 1, 2 and 3). The kidneys may be enlarged and the pelvis dilated, or may be small and shrunken due to chronic inflammation.

4. *Causes.*

The more commonly reported calculi in sheep consist either of phosphates or of calcium carbonate (carbonate of lime). Among the factors considered to contribute to their formation are the following:—

(a) *Vitamin A Deficiency.* When this vitamin is deficient certain changes occur in the lining membranes of the kidney and other parts of the urinary tract, leading to the formation of debris which may act as a focus for the accumulation of salts (e.g. phosphates and carbonates) present in the urine.

(b) *Imbalance of Calcium and Phosphorus.* It has been found that when the diet contains a great excess of calcium over phosphorus or *vice versa* the occurrence of calculi is favoured, particularly if Vitamin A is deficient.

Cereal grains and bran contain a gross excess of phosphorus over calcium, whereas with lucerne and clovers the reverse is the case. There is some evidence also that the amount of magnesium ingested may be a factor.

(c) *Mineralised Drinking Water.* It has been suggested that this may play a part, although the evidence is not very strong. It is possible, however, that waters containing high concentrations of calcium or magnesium might have the effect of balancing or unbalancing the mineral content of the diet and thus tend either to control or favour the occurrence of calculi.

(d) *Concentration of Urine.* A great reduction in the volume of urine may occur during hot dry weather, on a dry day or concentrated diet, or with lack of water. This concentrated urine is infrequently voided and, particularly, if the feed is rich in mineral salts these tend to deposit and form calculi.

(e) *Bacterial Infection.* Bacterial infection of the urinary tract is frequently found in cases of calculus but this may be the result and not a contributing cause of the condition.

5. *Prevention and Treatment.*

It is obvious that prevention must depend primarily on a knowledge of the particular factors contributing to the occurrence of the calculi, and the correction or modification of these factors.

Treatment is generally unsatisfactory. If the blockage is in the urethral process the calculus can sometimes be removed, or the process may be amputated. If the blockage is higher up the calculus can sometimes be massaged outwards. Even if the immediate obstruction is removed, however, recurrences are apt to follow.

With certain types of calculi, changing the reaction of the urine by administration of acid-forming medicines (or by starvation) is sometimes effective in dissolving calculi and, if continued, in preventing their formaton.

URINARY CALCULI IN WESTERN AUSTRALIA.

As indicated earlier the occurrence of calculi has been reported widely in this State but the condition appears to constitute a serious economic problem only in the Eastern Districts and in the "clover belt" where "clover stone" has caused the death of many valuable rams.

1. *The Eastern Agricultural Districts.*

During recent years losses of up to 10 per cent. of rams have been commonly experienced; in wethers the mortality appears to be higher. The following deaths were reported from five widely spaced properties in 1949:—30 out of 90, 41 out of 90, 50 out of 150, 50 out of 250, and 50 out of 500 wethers. The first four sets of figures refer to Merino weaners. A number of sheep owners have discontinued holding wethers beyond the age of about six months because of the heavy mortalities experienced even during their first Summer and Autumn.

Losses commence generally towards the end of the dry period, from March onwards and continue after the advent of green feed until June or July. In dry years deaths may commence earlier and cease later. Long dry seasons appear to favour the incidence of the condition; this was particularly heavy in 1949 when, moreover, losses were spread throughout the year.

Young animals, notably weaners and two tooths, appear most susceptible, but this susceptibility may be more apparent than real as it is a common practice in these areas for wethers and stud rams to be disposed of at an early age, so that only a small number of older males remain on the property.

It is evident that sheep maintained in good condition and heavily hand fed during the dry period are much more likely to be affected than those which are less well fed. Feeding on stubbles, unstripped oats, and with oat grain supplements from February or March until the advent of green feed is a fairly general practice throughout.

Few sheep other than Merinos are carried in this region so we have no evidence regarding breed susceptibility. Southdowns however, are known to be affected. The evidence to date indicates that serious losses are associated with heavy grey or red calcareous soils, under arid conditions. Only sporadic cases have been reported from similar soil types in "Lake Country" where sheep get a green picking throughout the dry period; or on "lighter" soil types.

With regard to water supply, information so far available suggests that this is, generally, not an important factor. It is, however, one which cannot be dismissed from consideration, and which will be investigated.

The Type of Calculus Causing Obstruction.

Although only a limited number of calculi have been examined so far it seems evident that two distinct types occur; either type may cause obstruction; both types may be encountered on the same property.

(a) *Calcium Carbonate Calculi.*—These are of the size and shape of small shot with a smooth polished "metallic" surface. They are hard in consistency and, commonly, greyish in colour. The colour, however, varies; in one instance gilded stones were found. They are found in the bladder and commonly cause obstruction of the urethra. On analyses these calculi are found to consist largely of calcium carbonate (carbonate of lime).

(b) *Siliceous Calculi.*—These are quite different in appearance. They are commonly of the size and shape of a grain of wheat but may be larger and may be irregular "chips." They have a rough uneven surface, are whitish in colour on the surface, and are friable or easily powdered. These calculi are apparently

Fig. 2.

(Am. Journ. Vet. Res.)

Debris in Pelvis of Kidneys—An Early Stage in Calculus Formation.

formed in the kidney and are found in the pelvis of that organ, giving an appearance like that in Fig. 2. They have been commonly encountered in the kidneys of ration sheep on one property where, remarkably, urinary obstruction has not been encountered in the wethers or stud rams. Few farmers appear to have observed these calculi in the kidney but it is believed that they must be fairly commonly present for it is evident that obstruction of the urethra commonly results from siliceous calculi; one ram breeder reported that he has frequently found them blocking the ureter in rams dying from urinary obstruction, in which case they were obviously derived from the kidney.

On analyses these calculi are found to be composed largely of silica, an inert substance which is present in large amounts in the soil (e.g. sand grains are composed largely of silica) and in many plants, notably in hay. It is known that the urine of herbivorous animals, as a result of their diet, may contain relatively large amounts of silica. Siliceous calculi however have been only rarely described in sheep, or in other animals, and nothing is known of the mechanism of their formation. There is some experimental evidence indicating that Vitamin A deficiency and other dietetic factors referred to are not responsible. This evidence, however, is not very convincing.

The calcium carbonate calculi on the other hand could be caused by one or more of the factors reviewed earlier, notably Vitamin A deficiency, mineral imbalance, and concentration of urine. The field evidence so far obtained in this State, does seem to suggest the possibility that Vitamin A deficiency is an important factor in the occurrence of both types of calculi. In this connection the appearance of the condition at the end of the dry period when the Vitamin A storage of the animal is at its lowest level, the increased incidence during long dry seasons, and the apparent protective effect of food containing Vitamin A (green feed during the wet months, and the green picking on Lake Country during the dry) does point in this direction.

It is obvious however that no conclusions can be drawn and recommendations made until the relative occurrence and importance of the two types of calculi is determined, and until we obtain more accurate knowledge of the various factors contributing to their formation in our environment.

2. *Urinary Obstruction on Parakeelia.*

Since 1925 we have received not infrequent reports of mortalities in wethers from ruptured bladder occurring when Parakeelia composed the dominant or only grazing available to sheep, notably in certain seasons in the Murchison.

It is only recently, however, that we have found that the urethral obstruction in these cases is due to the presence of calcium carbonate calculi, identical with the type described above.

It appears possible that the calculi may be formed under these circumstances on account of the demonstrably high oxalic acid content of the plant, Talapatra *et al* (1948) having shown that the consumption of excessive quantities of this acid by cattle may lead to high urinary excretion of alkaline carbonates. It is possible also that the plant may irritate the urinary tract thus contributing to the deposition and concentration of the calcium carbonate. Further evidence is required on these aspects.

Fig. 3.
Clover stone (above).
Stone removed from enlarged kidney (below).
Note: Stone moulded in shape of pelvis and calcyces of kidney.
(From "Disease of Sheep," by H. T. Carroll.)

3. *Calculi Associated with Subterranean Clover—"Clover Stone."*

Very early in the investigation of infertility of sheep grazing dominant subterranean clover pastures* we recognised that the presence of an unusual type of calculus in the kidneys of sheep was a common occurrence on clover properties. Some investigation of this condition was also carried out, but only passing reference has so far been made to it, the first detailed published description being that of Carroll (1949).

*See this Journal (1947), 23:1.

"Clover Stone." The calculi are formed in the substance of the kidney where small yellow, granules can be seen. These collect in the pelvis as "sand" which commonly aggregates to form a stone which becomes moulded into the shape of the pelvis and calyces of the organ. The calculus material is sulphur yellow in colour and the calculi are yellow throughout. They are moist, soft and very friable, being easily broken up. They vary in size from grains of sand to very large stones up to three ounces in weight, when the kidney substance is, not uncommonly, reduced to a shell surrounding the calculus (see Fig. 3). The kidneys may be enlarged and hypertrophied, or small and shrunken.

It is remarkable that despite extensive damage to one, or even both kidneys, ewes may be in good condition and in apparent good health. Wethers and rams, however, may show the usual symptoms of urinary calculus described earlier, yellow encrustations being common around the pizzle. Carroll has noted deaths in rams from urinary obstruction.

The calculi have been analysed in this laboratory and found to differ in chemical composition from any of the calculi reported in literature. The mineral content is extremely low, the total ash content being below 2 per cent.; the nitrogen content is very high.

The exact nature and mode of formation of these calculi has yet to be determined, but there seems no doubt that extensive grazing of subterranean clover (*Trifolium subterraneum* var. Dwalganup) is primarily responsible for their formation. It seems probable that they are composed principally of inflammatory exudates resulting from an irritant substance in the plant, the colour being due to pigments derived also from the clover. In that connection a rusty staining of wool around the urinary orifices is common in clover grazed sheep. It would appear that the prevention of "clover stone," as of infertility, must be based on measures designed to prevent sheep from regularly eating excessive amounts of subterranean clover. Detailed recommendations for the control of "clover disease" have been given by Shier and Rossiter (1949).

SUMMARY.

1. Present knowledge of the occurrence, signs, and possible causes of urinary calculi in sheep is briefly reviewed.

2. Our present, very incomplete, knowledge of this condition in Western Australia is presented and discussed in relation to findings elsewhere.

3. Urinary calculi, and the resultant urinary obstruction, are known to be the source of serious economic losses in the Eastern Agricultural Districts where an investigation of the problem has been commenced. The objects are the determination of the nature of the calculi responsible, and an understanding of the factors leading to their formation in order that preventive measures may be suggested, if practicable.

Evidence so far obtained indicates that two types of calculi, namely calcium carbonate and siliceous, are responsible for the condition in the region referred to.

4. Brief reference is made also to the occurrence of two distinct types of urinary calculi which result from extensive grazing on two specific plants namely Parakeelia (*Calandrinia spp.*) and Subterranean clover (*Trifolium subterraneum*).

REFERENCES.

Beveridge, W. I. B. (1942): *Aust. Vet. J.* 18 : 127.
Carroll, H. T. (1949): "Diseases of Sheep in W.A. and S.A.," H. T. Carroll, Perth, W.A.
Shier, F. L., and Rossiter, R. C. (1949): *J. Agric. West. Aust.*, 26 : 111.
Talapatra, S. K., Ray, C. S. and Sen, K. C. (1948): *J. Agric. Sci.*, 38 : 163.

Note.—The attention of sheep owners is drawn to the fact that an investigation of urinary calculi in sheep has been commenced and their co-operation is confidently invited. We should be glad to receive detailed information from those who have experienced trouble. Questionnaire forms for this purpose may be obtained on application.

Samples of calculi, together with particulars of age, sex, breed and state of health of the sheep from which they were obtained, and of position in the animal body, would be most welcome. Further specimens of "clover stone," however, are not required at the present time.

Correspondence should be addressed to the Principal, Animal Health and Nutrition Laboratory, Smyth road, Nedlands.

ACKNOWLEDGMENTS.

We are indebted to many sheep owners for their co-operation and interest and to Mr. H. T. Carroll for the loan of blocks from which Figs. 1 and 3 were prepared.

PHOSPHATIC SUPPLEMENTS FOR LIVESTOCK

Checking the Concentration of Solutions made from Superphosphate.

B. D. Stacy, Agricultural Adviser.

INVESTIGATIONS carried out by the Department of Agriculture during the last two years have shown that the blood phosphorus levels of cows in dairy herds in the South-West of this State have been subnormal (Snook, 1949). Quite a marked phosphorus deficiency was indicated by some of the low values obtained, and these low values have persisted throughout the year, even when abundant good quality green pasture was available.

The lack of phosphorus suggested by these observations could exert harmful effects upon milk production, reproductive efficiency and general health, so that renewed efforts have been made to impress upon the dairy farmer the importance of feeding phosphatic supplements. Nowadays the producer might greet this advice rather coldly, and scornfully point out that short supply and excessive cost have tended to deprive him of familiar orthodox mineral mixtures. Little help then to point to phosphorus deficiency if it occurred both in the dairy cow and the stock food market. It was to surmount this difficulty that feeding trials were carried out to test ways of utilizing the cheap and convenient supply of phosphorus in superphosphate. It should be pointed out that these experiments are still in a preliminary stage but the results to date have been promising.

In the September issue of the Journal of Agriculture it was described how, with thorough stirring, a concentrated phosphatic solution could be prepared by mixing 5 lb. of superphosphate with one gallon of water. The clear solution that formed after settling out was mixed with the cows' food and if properly prepared, half-a-pint of the solution supplied as much phosphorus as 4 ounces of bonemeal.

At this point the problem of "properly preparing" these solutions arises. A certain amount of stirring is essential, too much is waste of time—how can the farmer be satisfied that his solutions are of the right concentration?

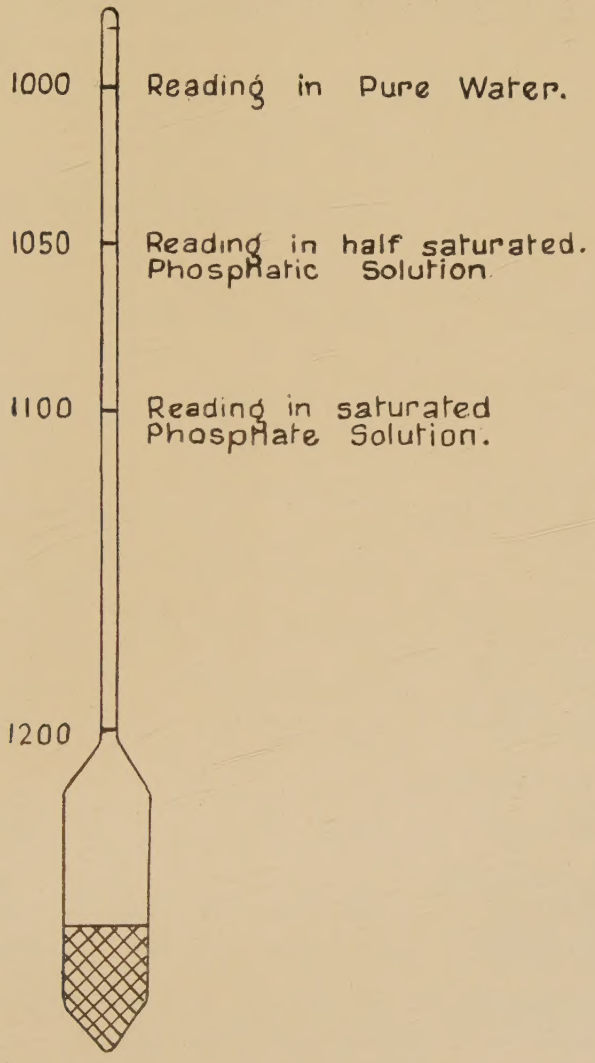
This difficulty can be rapidly solved by measuring the specific gravity of the solution, a simple operation involving the use of a type of hydrometer that can be purchased in Perth for about 18s. The required type is calibrated to measure specific gravities between 1.000 and 1.200, with graduations to show differences of 0.002. The hydrometers commonly used for testing car batteries are of NO use.

The specific gravity of a solution varies with the amount of dissolved material. This relationship can be seen in the following table, which shows a regular decrease in specific gravity with decrease in phosphate content.

Solution.	Mixture (ratio of weight of super. to weight of water).	Phosphate Concentration (as grams of phosphorus per litre).	Specific Gravity.
A	1 : 1	56.0	1.155
B	1 : 2	41.0	1.101
C	1 : 2.4	31.3	1.087
D	1 : 2.8	27.3	1.076
E	1 : 3.2	23.7	1.066
F	1 : 4	20.5	1.052

Solutions of the type B above made by mixing 5 lb. superphosphate with one gallon of water, are of the recommended concentration and have a specific gravity very close to 1.100.

Using the correct hydrometer the specific gravity may be rapidly measured, hence avoiding wastage due to under or over stirring.



Method of Use.

1. Thoroughly mix water and superphosphate.
2. Allow to stand until undissolved material has settled.
3. Place hydrometer in a froth free portion of solution and take the reading.

If the reading is close to 1.100 (say 1.090 or higher) no further stirring is necessary. If the reading is less than 1.090 either more stirring or more superphosphate is necessary.

Reading the specific gravity from the hydrometer may be made easier if some of the solution is collected in a deep wide-mouthed glass container (e.g. a pickle bottle).

Reference.

Snook, L. C. (1949): J. Dept. Agric. W. Aust., 25, 169.

ANALYSES OF FEEDING STUFFS.

Department of Agriculture,
Perth, 1st February, 1950.

Results of Analyses of Samples of Feeding Stuffs taken under the Feeding Stuffs Act, 1928-1948.

(Published under Section 9 of the Act.)

Date Sample taken.	Firm and Brand.	Crude Protein.	Crude Fat.	Crude Fibre.	Sodium Chlor.	Phosphoric Acid P_2O_5.	Lime.	Others.	
		%	%	%	%	%	%	%	%
	Barrow Linton & Co.								
	" Dukko " Fattening Mash—						Ca.		
	Reg. Analysis	†10.0	†4.0	*4.0	*1.0	....	3.0	....	....
9-9-49	Sample Analysis	14.7	4.4	5.3	1.66	....	1.88	....	....
	Broome Freezing and Chilling Works.								
	" Broome " Meatmeal—						CaO		
	Registered Analysis	†60.0	*10.0	*10.0	....	11.0	11.0	....	....
20-6-49	Sample Analysis	43.7	16.0	2.1	....	11.8	15.0	....	....
	W. R. & N. N. Clarke								
	" S.M.P." Meat and Bone Meal—								
	Registered Analysis	†50.0	*13.0	*2.0	....	....	....	....	....
5-8-49	Sample Analysis	42.9	7.9	1.4	....	....	....	....	....
	" Aberdeen' ' Meat and Bone-meal—								
	Reg. Analysis	†48.0	*15.0	*2.0	....	....	....	....	....
15-9-49	Sample Analysis	49.1	8.6	1.04	....	....	....	....	....
	David Gray & Co., Ltd.						Ca		
	" Western " Sweet Dairy Food—								
	Registered Analysis	†12.0	†3.0	*10.0	*1.0	....	*0.8	....	....
4-8-49	Sample Analysis	13.3	1.8	4.4	0.37	....	0.16	....	....
	" Western " A1 Laying Mash—								
	Registered Analysis	†14.0	†3.0	*5.0	....	....	0.8	....	....
5-8-49	Sample Analysis	14.8	3.0	4.5	....	....	0.52	....	....
	" Western " Laying Mash A—								
	Registered Analysis	†14.0	†3.0	*5.0	....	....	*0.8	....	....
24-8-49	Sample Analysis	12.0	2.2	4.1	....	....	0.31	....	....
	Davis Gelatine Co.								
	" Tri-Calos " Sterilised Bone Flour—						CaO		
	Registered Analysis	†5.0	....	....	....	†30.0	†40.0	....	....
26-8-49	Sample Analysis	6.62	....	....	....	31.8	42.6	....	....
	W. H. Milne & Co.								
	" Millers " Fattening Mash—						Ca		
	Registered Analysis	†12.0	†4.0	*6.0	*1.5	*2.0	*3.5	....	....
24-8-49	Sample Analysis	15.6	4.9	5.64	1.76	2.8	2.48	....	....
	" Millers " Chickstarter—								
	Registered Analysis	†15.0	†4.0	*5.5	*1.5	*2.0	*3.0	....	....
16-9-49	Sample Analysis	18.6	4.0	5.1	1.28	2.25	1.79	....	....
	State Abattoirs.								
	" Midland " Meatmeal—								
	Reg. Analysis	†51.0	*19.0	*2.0	3.0	....	3.0	....	....
16-9-49	Sample Analysis	56.6	4.3	2.70	4.28	....	3.51	....	....
	W. Thomas & Co. (W.A.), Ltd.								
	" Thomas " Sweet Dairy Food—								
	Registered Analysis	†14.0	†1.5	*8.5	*2.0	....	*4.0	....	....
4-8-49	Sample Analysis	13.0	3.4	6.0	0.97	....	1.6	....	....
	Branato Wheatmeal—								
	Registered Analysis	†8.0	....	*10.0	....	....	....	....	....
24-8-49	Sample Analysis	10.1	....	3.4	....	....	....	....	....
	" Thomas " Calf Food—								
	Registered Analysis	†20.0	†2.5	8.0	3.0	....	*10.0	....	....
							†6.0		
26-8-49	Sample Analysis	25.0	2.5	8.0	1.42	....	3.0	....	....
	" Thomas " Laying Mash No. 2—					....		....	....
	Registered Analysis	†14.0	†2.5	*7.0	*1.75	....	*3.75	....	....
21-8-49	Sample Analysis	14.2	3.8	5.1	0.85		3.07		
	" Thomas " Pig Grower—					....		....	....
	Registered Analysis	†12.0	†2.5	*6.5	*2.0	....	*4.0	....	....
24-8-49	Sample Analysis	14.7	5.1	3.9	1.90		3.94		
	" Thomas " Quicklay—					....		....	....
	Registered Analysis	†35.0	*12.5	*4.0	*6.0		*15.0		
					†2.0	....	†10.0	....	....
26-8-49	Sample Analysis	42.6	9.2	1.4	6.67		10.4		
	" Thomas " Chickstarter—								
	Reg. Analysis	†18.0	†2.5	*6.0	*1.0	....	*3.75	....	....
16-9-49	Sample Analysis	19.8	4.4	4.9	1.06	....	1.75	....	....

* Maximum. † Minimum.

Analyses of Feeding Stuffs—*continued.*

Date Sample taken.	Firm and Brand.	Crude Protein.	Crude Fat.	Crude Fibre.	Sodium Chlor.	Phosphoric Acid P_2O_5.	Lime.	Others.	
		%	%	%	%	%	%	%	%
	The W.A. Meat Export Works.								
	"W.A.M.E." Meatmeal—								
	Registered Analysis	†45.0	*13.0	*2.0	....	....	....	....	....
5-8-49	Sample Analysis	44.8	11.7	2.0	....	....	....	....	....
	Westralian Farmers Co-op., Ltd.								
	"Wesfarmers" Sweetened Dairy Meal—							Copper	
	Registered Analysis	†11.0	†2.5	*6.0	*1.0	....	*1.00	.003	....
4-8-49	Sample Analysis	10.8	2.3	5.3	1.9	....	1.55	0.02	....
	"Wesfarmers" Chickmash "B"—								
	Reg. Analysis	†14.0	†4.0	*7.0	*1.0	....	*1.0	....	....
15-9-49	Sample Analysis	16.2	5.2	6.2	0.92	....	1.63	....	....
	"Wesfarmers" Chickmash "A"—:								
	Reg. Analysis	†15.0	†4.0	*7.0	....	....	....	....	....
15-9-49	Sample Analysis	15.4	4.8	6.3	....	....	....	....	...
	R. B. Young.								
	"Morlay" D Mash Fattening—					....		....	....
	Registered Analysis	†10.5	†3.0	*5.0	*1.5	....	*4.0	....	....
25-8-49	Sample Analysis	13.9	3.1	5.2	0.84		2.93		
	'Morlay" Laying Allmash—					....		....	....
	Registered Analysis	†13.0	†3.0	*6.0	*2.0	....	*4.0	....	....
25-8-49	Sample Analysis	14.3	3.7	5.2	0.86		3.11		
	"Morlay" Growing Allmash—								
	Reg. Analysis	†12.0	†3.0	*6.0	*2.0	....	*4.75	....	....
14-9-49	Sample Analysis	17.5	3.6	6.1	1.70	....	1.89	....	....

* Maximum. † Minimum.

Editor's Note.

Dairy Herd Improvement Scheme, pp. 333-357, Vol. XXVI., No. 4, December, 1949.

Further figures were received from the Nannup Unit too late for inclusion in the above article.

These figures show that wastage in that unit was 104 cows instead of 22 as shown in table 9, page 341.

It has not as yet been possible to segregate the 104 disposals under the various headings in the table but, when they are taken into account, the total wastage for all units is 17.5 per cent. instead of 16.9 per cent. as per line 2 on page 340.

By Authority: WILLIAM H. WYATT, Government Printer, Perth.